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New York Barge Canal Much attention was given in the public prints some time ago to the need for organizing and training a permanent operating force for the Panama Canal. It is not so well realized, however, that the New York State Barge Canal has reached the stage where attention must be paid to the same matter. This undertaking, costing somewhat more than a third as much as the Panama Canal work, will soon enter its final stages. The State engineer urges, therefore, that the Legislature enact laws under which the operating organization can be recruited and perfected. That this is a large problem can be appreciated when it is reflected that the system embraces 440 miles of canal, with about 50 locks and a great many terminals. The problem, therefore, is quite different from that at Panama, and, in fact, from that presented by any other canal in the world. Something can be learned, it is true, from the operation of canals in other countries, but the modifications of practice found satisfactory abroad will naturally be material. Moreover, comparatively little can be learned from the history of the Erie canal. The passage of the mule as motive power and the demand for efficient handling devices at terminals impose conditions that the older waterway did not know. In connection with the handling devices the State engineer has followed the safe course, letting contracts, up to the present, for the main structure only—the dock itself—and reserving decision as to mechanical equipment to as late a date as will be consistent with simultaneous completion of the waterway and the terminal facilities. By so doing more American experience as to freight-handling equipment will be available for the guidance of the Barge Canal's designers. At present the electrical apparatus for the operation of the locks is well on toward completion, and since the proper care of this apparatus will require technically trained men, it is apparent that action looking toward the organization of the operating forces should not be longer delayed.

Small-Cube Pavements Some years ago much attention was attracted to the small-cube pavements laid at Rochester, N. Y. A complete record of the results to date will be found on page 624. It appears, however, especially in view of the high hopes that were entertained, that Mr. Harger's optimism is at variance with his own testimony, although since that testimony is so unmistakably phrased no harm can result. In the case of those Monroe County pavements which have been laid long enough to permit conclusions to be drawn, the concrete cubes have failed to give satisfaction, while even the vitrified shale cubes have indicated a relative failure, because of the need for a bituminous surfacing. A coat of oil or tar is a considerable item in maintenance expense. The intimation that its use is necessary in this type of pavement will give the shale cubes a decided setback. Another disappointment lies in the failure of the home-made cubes. One of the strongest arguments of the early advocates was that the cubes might be made of local material—conducing to economy—but this was not borne out at Rochester. Whether it will be valid at other points depends on local conditions, but no section or city can feel safe in predicting economies on the same account without getting, in advance, the advice of a competent specialist in ceramics. The statement that the concrete cubes laid on the Newport House Road in 1913 give promise of satisfaction places much of the blame for former failures on lack of skill in manufacture. The conditions, therefore, still hold forth some hope of ultimate success. Another encouraging feature is the advance in methods of laying the pavement, particularly in getting close joints with pallets. The reduction in cost of making the shale cubes at Corry, Pa., in June of this year gives weight to Mr. Harger's belief that they may be able to compete with bituminous macadam. All of these optimistic reflections, however, seem to be based on this year's developments. If a general conclusion is to be drawn from the pavements which have seen service, it is that they have not been a success.

Title-Page Honesty Experienced book-buyers and readers are accustomed when seeking the date of publication of a work to pass over the figures on the title page and look for the copyright date. In other words they have learned that a book plainly dated "1913" on its title page may be quite hoary, as the ages of books go in this rapidly moving world. Is this a species of dishonesty? If the intent be judged the answer must often be no. The publisher is merely following an old custom. In reality, however, the inexperienced are deceived and to that extent injustice is done. The custom of changing the title page date to the year of the given impression, despite the fact that the book has undergone no change, appears like a relic of the day when every man expected that the price of a book was inflated and demanded—and generally got—a discount. Book selling has, however, progressed to a new basis. The old list prices are disappearing and only net prices are quoted. With the change has come a new view of title-page dates, and we now see books marked "First Edition, Second Impression," retaining the original title-page date, whereas formerly, and even now with some publishers, the same book would have been called "Second Edition," and have borne the year of printing. Just where the line between "edition" and "impression" shall be drawn is a matter of judgment, and judgments will vary. Certain it is, however, that correction of a few errors should not constitute a new edition, while a total or extensive revision may legitimately be so called. A popular magazine recently presented its views on the subject. "When publishers reprint old books with new dates on the title pages," it said, "and with no explanation, are they fooling the reading public? If a shoemaker should attempt to sell you old stock with new labels on it, wouldn't you feel that he was playing tricks with you? And isn't your mind more important than your body? Why should anybody be deluded into buying a last year's book any more than a last year's straw hat?" The matter is one of special importance in technical works, for progress is rapid and frequently the book issued three years ago has lost much in value. It is time that all publishers adopted a uniform style and let the title page stand for the book.

New Houston Charter Houston, Texas, was one of the first cities to adopt the commission form of government. Apparently it did not at the same time drop into an attitude of self-complacency, but has applied itself to the problem, as it sees it, of improving upon its original work. At an election held on Oct. 15 thirty-six amendments were adopted, aimed, in the main, at enlarging the city's powers, as permitted by a new act of the Legislature, and giving it complete home rule. One of the amendments provides that the city may condemn, build, own and operate "any and all buildings, establishments, institutions and places, whether situated inside or outside of the city limits, which are necessary or convenient for the transaction of public business or for promoting the health, morals, education or welfare of the inhabitants of the city, or for their amusement, recreation or benefit." This certainly gives a city latitude to do anything it wishes. To what extent it can go may depend, eventually, upon court decision; but on the surface it is difficult to set the limit under this broad enabling clause. This view is further strengthened by specific statements in the amendment that the city may build, own and operate tenement houses, steam laundries, ice factories and bakeries. While municipal activities have been expanding rapidly in recent years, the step indicated by this amendment sets a new pace in city government. Just how it should be evaluated is a question that can be answered only after long and careful discussion of all the reasons actuating the citizens of Houston and of the effect on private business. It is very easy to get up enthusiasm over the possibilities which such a charter holds of curbing oppressive monopoly, but it is not so easy to predict that these many activities will eventually be satisfactorily administered and will be of lasting benefit. Municipal ownership versus municipal control is still a debated question, though when the results are compared the balance still is strongly in favor of municipal control. It is evident that Houston will not engage in all of these activities at once, and so by making haste slowly may learn that it had better attempt to control the activities than to operate them. The enlarged powers under this charter are an evidence, however, that in Houston at least faith in municipal efficiency is stronger than it is in many sections of the country. Were it certain that a competent and honest management could be insured indefinitely the Houston idea might spread rapidly, but in the present stage of our political life wisdom dictates that experimentation should proceed slowly.

The Slimy Trail There is no pleasure either for author or reader, provided both are right-minded, in raking over a foul-smelling mass of political corruption merely for the sake of exposing the nauseating mess. The conditions recently disclosed in connection with highway work in New York State, however, so intimately concern both main classes of the Engineering Record's readers, engineers and contractors, that brief consideration is called for. The conditions are those which in any governmental work—State or municipal—tend to prevent decent contractors from bidding on work, and force engineers out of the service or deter them from entering. Details of the disclosures are not necessary. Suffice it to say that there has been a systematic mulcting of contractors doing State work—blackmailing would be a better description, for even though there were no threats, recalcitrants knew what treatment to expect. The really amusing feature of the disclosures is the innocent wonderment with which the residents of the State are supposed to view the shameful testimony. The "holding up" of highway contractors and "shaking down" by the henchmen of the dominant political organization is nearly as old as the first $50,000,000 bond issue. But even then it did not originate with the initiation of extensive highway work, for the system had already been perfected by operating on Barge Canal contractors and civil service employees in the State Engineer's department. Early each fall a small fleet of political Captain Kidds cruised through the State, firmly and not always gently removing tribute from chainman and contractor alike. No doubt there were exceptions, but, notwithstanding, the system was, and is, as generally recognized as its age and remarkable efficiency deserve. The change in administration three years ago was indicated only in a more candid and business-like manner of soliciting the sinews of war. The effect of such conditions is evident. Competent men are driven from the service, while contractors insofar as possible endeavor in their bids to make proper provision against the annual financial separation. Neither the people of New York nor of any other State can expect continued competence in either engineers or contractors under such a system.

Groined-Arch Vaulting

The groined arch forms probably the most economical arrangement of concrete for producing a strong, reliable roof for filters, reservoirs and similar structures. One has only to see a 10-ton roller pass over vaulting 6 in. thick, with spans of from 12 to 14 ft. without damage, to realize this fact. The great amount of this vaulting that has been built in the United States since it was introduced by William Wheeler at Ashland, Wis., eighteen years ago, the rough usage that it has received and the small number of accidents are confirmatory evidence. Nevertheless there have been a number of failures, and they seem to have been more frequent recently. This suggests a growing carelessness and need for more careful consideration of the conditions of stability.

The first secret of the strength and economy of the groined arch is that every part of the structure is in compression. In vaulting as most commonly built the horizontal thrust when loaded amounts to about 2 tons per running foot. This thrust, or that part of it which results from the loading that exists at the time, must be provided for before the centers are struck. There is a strong tendency to carelessness and only constant vigilance on the part of the supervising engineer can hold this tendency in check. It is always difficult to convince workmen and superintendents of construction that a roof that is so strong that a steam roller may pass over it needs special attention in the details of striking centers.

Another essential for strength and stability in the groined arch is the presence of a secure and reasonably unyielding foundation. In most of the filters and reservoirs provided with groined arches such a foundation has been secured by the use of the inverted groined arch as a floor. In other words, the bottom has been built like the top but turned bottom side up, and with such modifications in design as the change in position suggested. With this arrangement the floor arches are under even greater compression than the roof, and the thrusts are transmitted to the outside walls and the embankments outside of them. Such a floor distributes the great load of the roof, the filling over it, and the still greater load of the water in the structure, when in service, over the whole area in a more or less uniform manner.

Experience with floors of this type has shown that they may be raised by frost during construction and that afterward they go back to place with little damage, and that moderate settlements in the underlying materials will be followed by the masonry. Notwithstanding the precautions frequently taken to prevent the freezing of material under partly completed work, it is probably true that there has been more or less lifting of structures by frost in nearly all the large plants built in cold climates, the construction of which has extended over more than one year, and with few exceptions the structures have gone back to place without damage.

Failure to provide adequately for the floor thrust by leaving too large openings for underdrains or other purposes has frequently led to movement of the concrete and to breakage, and occasionally to reconstruction in which better bracing has been provided.

In a number of recent designs a reinforced spread foundation with a flat floor has been used in place of the inverted arches. On rock this has some advantages, but experience shows that on sand or clay there is frequently compression or movement under general loading, even though tests on small areas before construction showed sufficient bearing power. Under these conditions there may be an unequal movement of a flat floor and of the supports for the piers which tends to disrupt the floor system and to disturb the equilibrium of the groined-arch roof above. Such movements may also be caused by frost action, which lifts and breaks the floor between the piers so that it will not settle back to place.

It may be that such movements of the foundations contribute to lack of stability and failure in groined-arch vaulting, even where there are other elements of weakness. Without disparaging such other elements and the precautions required to counteract them, it may be suggested that the failures in concrete groined-arch structures during the last few years disclose a surprisingly large proportion among the relatively small number of structures that have been provided with flat floors and spread foundations resting upon sand or clay.

In view of this condition the question may well be raised as to whether the flat floor and the spread foundation as built may not have shown themselves inadequate, and thus have been at least contributing causes in the unfortunate accidents that have occurred.

City Planning and the Engineer

Attention has been directed in this journal at various times to the progress made in the "city planning" movement, and of the part the engineer must play in this work. Unless one is in direct touch with it, however, it is impossible to realize how great an interest has been aroused and how many have been the steps, in one direction or another, in carrying out schemes which come under that head. There are, in addition, many more plans that have matured but have not yet been executed, and still others are in various embryonic stages.

Some idea of the work done along these lines in recent years can be gathered from the experience of those in charge of the city planning exhibition held under the auspices of the Heights of Buildings Commission of New York City. A call for exhibition material was sent out to professional men engaged in such work, to cities, manufacturers, civic associations and others interested. The result was a deluge of exhibits, mounting into the thousands—three times as many as the exhibition room provided, and deemed of ample size, would accommodate. They were in the form of photographs, sketches and drawings, and, for exhibition purposes, were divided into the following groups: Comprehensive city improvement or development plans, civic centers and public buildings, parks and playgrounds, housing, industrial villages, water supply and sanitation, planning of streets, transit, waterways, docks and bridges, and waterfronts.

Every conceivable phase of the influence of the material make-up of the city upon its citizens seems to have been considered. This is in contrast with some erroneous notions, that the whole of city planning is included in the making and carrying out of plans intended solely to enhance the beauty of the city. Transit, commerce and manufactures cannot be neglected, while the physical well-being of the citizens, as affected by satisfactory housing, sanitary conditions, and recreation facilities, forms another important division of the city planner's work.

While the selection, from the comprehensive list, of one or two subjects of special interest is quite difficult, it can be said with comparative safety that few exhibits seemed to receive closer attention than that on housing. Views of the remarkable "garden cities" of England could not but bring up by contrast the disgraceful mill towns erected by industries in this country. Letchworth, founded only ten years ago, has a population of 7000 with thirty industries. One of the Liverpool exhibits was quite illuminating, showing a given area developed as the law allowed, with forty-one dwellings per acre, and as actually carried out, with but eleven dwellings per acre. That progress has been made in this country, moreover, was evidenced by the views of Enola, the town built by the Pennsylvania Railroad for its employees.

In connection with this exhibition was a display of a remarkable set of maps prepared for the Heights of Buildings Commission. These were about 140 in number, arranged in three groups. In the first were perspectives and photographs among tall office buildings, showing their effect on light conditions and street congestion. In the second were maps showing by typical examples the height, area and type of occupancy regulations of various cities of Europe and America. The third group contained maps of the five boroughs of Greater New York, illustrating the distribution throughout every part of every borough, of a number of different aspects of property use. By an appropriate color scheme they give, with but little study, a comprehensive view of all the factors with which such a commission would be expected to deal. Some remarkable conditions, which will be fully analyzed in the commission's report, are shown. For example, while in the Borough of Manhattan about 85 per cent of the buildings are four stories or more in height, with about 75 per cent of the lot areas covered by buildings, in Brooklyn about 60 per cent of all buildings are under three stories in height, with only about 40 per cent of the lot areas covered. It is apparent that the handling of the problem presented by these diagrams falls within the scope of city planning as above described. That it will require the aid of engineers for its solution needs no demonstration.

If the signs are rightly read, therefore, it would appear that municipal engineers will need more and more frequently to pass on or aid in the development of city planning schemes. It behooves them to be prepared.

The Iron Age of Architecture

It is the joy of many to abuse the present and laud the past, but it has been given to few so to rouse an architectural hornet's nest as did a writer in a London paper recently in bemoaning the passing of the craftsman from his one-time leadership. Lamenting that the master builder of mediæval times had given place to the mere architect of to-day, he brought about his ears the whole protesting swarm. Now granting that there were giants in those days who left behind them monuments of such eternal beauty that they have been the chief inspiration of all that has come after, it is by no means true that the merit belongs to the builder or the craftsman alone. The great work of antiquity was wrought by the combination of artist and mason in proportions now unknown, with time as their silent partner. However the creative mind began its career its host was usually sleeping in the crypt it had planned a century or so before the building, as we know it, was finished. As to the most of mediæval work, it has gone to well-deserved decay long since. We let our imaginations run riot in dreams of the faithful workman's loving artistry, forgetting the nameless and pestilent bunglers whose clumsy fingers wrought abominations in wood and stone. And few even of the masterpieces have escaped the stupid and ruthless meddling of the renovator, whether architect or builder by training.

No, the old days were as full of bad design and worse execution as our own. The ruins of St. Mary's Abbey in York, for instance, show as vile a grade of rubble as any cheap contractor of the twentieth century could imagine and the building tumbled easily into the decay it deserved. Some of the good and stable work of the past has happily remained to us and has served as a model from century to century. The ordinary architect of to-day makes fewer mistakes by copying it than by trusting to his own imagination. Whether his predecessor began as artist or as mason makes precious little difference.

But before passing hasty judgment upon the architect of our own times, think a moment of the evil days upon which he has fallen. In the mediæval times he must perforce know only the technique of masonry—the rest was his art. If he were building a church the fine stimulus of the Gothic was his inspiration and his medium was craftsmanship in stone. To-day he must know masonry and concrete, structural steel and sanitary plumbing, lighting and heating, electric wiring and acoustics. The old congregation did not need to read and mostly couldn't, expected to be cold and generally was, could not understand the Latin of the service even if it chanced to hear it. Little need for wonder or blame then if the architect, having to be a Jack-of-all-trades, bungles a goodly number of structures if he tries to cover the whole range single handed. His training is of necessity spread out rather thin, and the wonder is not that he sometimes does badly, but that he ever succeeds in rising out of the turmoil into greatness.

Besides all this he has to struggle against or make surrender to a complex commercialism that makes the machinery of construction terribly intricate. His predecessor did not have to plan for buying his stone from one source, his steel from another and his woodwork from a third; he was not hounded by agents of patented devices nor pestered by circulars of supplies offering him "the usual architect's commission of — per cent." If he were a grafter it was by malice prepense, and not by daily temptation. All these things the architect of to-day has to endure, besides being called a slavish copyist if he turns to the best in antiquity and a commonplace innovator if he does not.

His chief hope is in suiting himself as best he may to new conditions, calling in technical advisers on the details which he cannot in the nature of things have time to master, even if he has the ability, standing the more firmly by the interests of his client as he confronts a regiment of subcontractors, and remembering that he must be artist before being engineer or contractor. Originality and resourcefulness is much more difficult to find than technical or constructional skill, and if the architect is to be more than a master mason or boss concrete mixer it must be by the possession of these attributes. And looking about one cannot but realize that art did not die with the Gothic nor perish with the Romanesque. New necessities must bring new forms now just as certainly as they did a thousand years ago. And if the sketches of the Cathedral of St. John the Divine reincarnate the inspirations of the past, just so surely does the fine mass of the the West Street Building, rising like a huge ancient keep against the Western sky as one passes out onto the North River, bespeak the promise and the dignity of the age of steel. The times have changed and the architect must change with them.

Unification of Power Supply

The strongest tendency in the modern development of electrical supply is toward the consolidation of systems—not merely financial union, but actual physical aggregation, gathering into one great network all the systems which have grown up over a widespread territory. The beginning of such work has very commonly been the extension of electric service from an existing central station into neighboring districts by the ordinary growth of distribution systems, and often by the acquisition of small outlying plants and their connection to the main source of supply. The immediate result of consolidation is economy in the management of the business, the possibility of cheaper generation of energy, and usually the reduction of price to the consumer as the natural result of the improved situation. This sort of gathering into a great unified system has been going on for a good many years and has resulted in many of the large central stations in our bigger cities covering greatly increased spheres of activity, extending often to hundreds of square miles. The gains in general efficiency are conspicuous. Small plants, costly to operate, are abolished and their places taken by substations fed from the main source of supply. The original tendency in working along this line was to build enormous power stations and to concentrate as far as possible the full generating system under a single roof. This plan has reached its economic limits and the leaning now is toward the supply of the whole network from several stations conveniently located.

This process of evolution has been strikingly illustrated in the growth of the Commonwealth Edison Company, of Chicago. The ultimate result of a great consolidated load is a highly economical station, and it has rapidly been made evident that, once the business of generating electrical energy has reached sufficient magnitude, not only lighting and comparatively small power loads but railway operation and other large demands, which ordinarily have been handled by separate plants, can profitably be taken care of by the central-station system so as to secure still greater economy and efficiency. Even when the power supply of a railway, for example, is on so large a scale as to insure very economical generation it still remains true that that there may be considerable advantage in turning over the work to a great central-station organization because the number of independent distribution systems working over the same territory is reduced.

This stage of evolution has been reached by the great Chicago system to which reference has been made. All the power for the surface railways of Chicago and the five elevated systems as well will, under contracts just executed, be supplied by the Commonwealth Edison Company, which already has thoroughly covered the territory with its own distributing system for power and light. It is clear that, apart from everything else, three independent distribution systems cannot supply a given region as effectively as one. If there were no other reason the mere difference in the demands of the three systems with respect to time and space would sufficiently justify the concentration. Every electrical system, for whatever purpose, is handicapped in its regulation and in its efficiency of distribution by the wandering of its load, which shifts from hour to hour in average position in response to the particular demands of the community. When a number of systems, each with its own peculiarities of wandering load, are tied together there is an excellent chance of utilizing for the shifting load of one the otherwise unavailable conductors of another. Likewise the variation in time of the demand at various points of the system lifts the load factor of the combined generating stations to a point which could not be reached by any one of them alone.

The development in the Chicago situation is, therefore, strictly a logical one. Moreover, it is carried further in its logical development by provisions through which the central station takes charge not only of the distribution and transmission of power for the railways but also of much of the converting apparatus which supplies direct current for the working conductors. In other words, we have here the whole electrical service of the city, worked from united generating stations over a network consolidated so as to obtain the most economical possible results in distribution. That the results, from the standpoint of cost, are quite certain to be satisfactory is amply proved by the making of the present contract. Big corporations do not buy power unless it is worth their while, nor sell it without a fair profit.

The Chicago system is, in a word, the most remarkable example of progress in the theory and practice of power development.

Small-Cube Pavements of Monroe County

Service Tests and Costs of Two-Inch Blocks of Gravel Concrete, Clay Ash and Vitrified Shale Laid Since 1908 near Rochester, N. Y.

By W. G. HARGER

First Assistant Engineer, New York State Highway Department

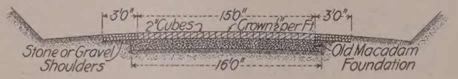
PAVEMENTS of small cubes, from 2½ to 4 in. on a side, similar to the German "kleinpflaster" or the English "Durax" types, have been considered too costly to warrant general use on country roads in the United States, although a machine has recently been developed to reduce the expense of producing the blocks. There has been so much more hope in the perfection of brick and bituminous roads at a medium cost that the use of the cube method has been delayed. In 1908 Mr. J. Y. McClintock, county engineer of Monroe County, New York, undertook to get the benefit of this system at a reasonable price by using artificial cubes made of local materials and began a series of experiments in an effort to show the value of this type of pavement. It is natural for a new construction to have a percentage of failures, but these failures carefully analyzed are as valuable as the successes, for they indicate the limitations of the different materials and methods. The pavement has passed through the experimental stage and demonstrated that it promises well for certain localities and certain traffic conditions and that it is entitled to consideration.

In 1908 15,000 2-in. cubes were laid in crosswalks in Reservoir Avenue and at Charlotte across the West Side Boulevard, near Rochester, N. Y. These cubes, which were made of the ordinary vitrified pipe mixture—16 per cent red clay, 52 per cent local yellow clay and 33 per cent Jersey clay—laid on a concrete base, with grouted joints, are in perfect condition to-day on the Reservoir Avenue crosswalks. They show less wear than the paving bricks on both sides of them. The traffic is largely automobile, but is heavy. The Tarvia macadam on this road has been repaired twice since 1908. The cubes in the crosswalks at Charlotte were laid in the same manner, except that they were humped purposely to reduce the speed of automobiles in the village. The traffic on this road is heavy and hits these cubes with a strong impact. They show wear, but less than would naturally be anticipated under the conditions.

In the same year 2000 cubes of various materials, which had accumulated in the city laboratory where the first tests were made, were placed in the Penfield Road. The macadam was picked out in a strip 2 x 10 ft. and the cubes were laid, tamped in and the joints filled with sandy loam. Fig. 1 shows their condition to-day after five years of ordinary farm-road traffic, a combination of teams, automobiles and agricultural engines.

First Gravel Concrete Cubes

In 1909 730,000 2-in. local gravel concrete cubes covering 2650 sq. yd. were manufactured and laid as a resurfacing on the old macadam of the Ridge Road near Rochester, at a cost in place of 51 cents per square yard. The details of manufacture and cost were described in the Engineering Record of March 5, 1910. The concrete was made rather dry, molded in a machine and tamped. The local gravel used was soft and would not be considered first-class concrete material. The old 16-ft. macadam road, averaging in thickness about 4 in., had a very rough and knobby surface. This was evened up with a cushion of fine gravel, upon which the cubes were laid by hand 15 ft. wide; no attempt was made to break joints. They were rolled with a 10-ton steam roller, and the joints were filled with sandy loam flushed and broomed in. Temporary shoulders of 2-in. plank were put down during the laying of the cubes and afterward removed and replaced with broken stone or gravel. The crown was ½ in. per foot.



Concrete Cubes Used on Old Macadam

The traffic on this road is a heavy, mixed travel. In the fall of the year a great many agricultural engines with sharp lugs pass over it. The cube surface wore down rapidly but evenly and gave a satisfactory surface and good footing in both wet and dry weather for two years, at the end of which time it failed in large areas. It showed no tendency to ravel or break down at the edge. Before failure the surface lost its true shape in spots, which was probably due to the unequal depth of the gravel cushion. This defect was not a serious one and has been remedied in the 1913 work. The experience with the 1909 concrete cubes warrants the following conclusions: The small cube form is flexible under frost action and is, therefore, a suitable top for a macadam foundation in Northern climates. The edge of the cube pavement can be successfully held with a macadam shoulder, which makes a gradual transition from the hard surface of the road to the dirt shoulder and prevents ruts forming along the edge, a serious defect in any form of concrete or stone edging. Too great a variation in depth of the sand cushion under the cubes is not safe, and the local gravel concrete cubes will not stand heavy traffic directly on their surface. All of the work since 1909 has borne out these conclusions.

Seventy-four thousand 2¼-in. vitrified shale cubes made at Reynoldsville, Pa., were also laid on the Ridge Road in 1909 in the manner described, at a cost in place of $1.17 per square yard. Being the first experimental lot from this plant, they were not as well or as uniformly burned as a good paving brick. Considering this fact and that they were laid unculled, they have stood up wonderfully well (see Fig. 2). The shape of the road is nearly perfect. The cubes confirm the claim of flexibility under frost action and stability under traffic and show two faults of construction, however, which have since been remedied. The joints are too wide and the sandy-loam filler has been sucked up and kicked out by the fast-moving auto traffic, leaving a joint open at the top, which has resulted in excessive spalling and wear along the joint lines. These cubes were laid separately by hand directly on the sand cushion. This is a back-breaking job for the men and they do not get a close joint. The cubes are now laid 128 at a time from pallets, affording a very close joint. As now laid, a thin coating of Tarvia B or No. 4 road oil is spread over the surface of the completed cubes; this coat wears off from the surface in a short time, but remains in the upper part of the joints and holds the filler in place, protecting the edges from spalling.

A slightly better burned cube, laid in the improved manner, would undoubtedly have been perfectly satisfactory on this road. The price of $1.17 per square yard is excessive for resurfacing on roads of this character, but it must be remembered that this is an experimental price. The cost at the plant was approximately $3.20 per thousand, or 71 cents per square yard. There is every reason to believe, from the simplification in burning that has been proved feasible this season, that the cost at the plant for large orders will be about $1.60 per thousand, or 35 cents per square yard. On this basis cubes can be economically used in competition with bituminous macadam.

In 1910 1,530,000 concrete cubes and 400,000

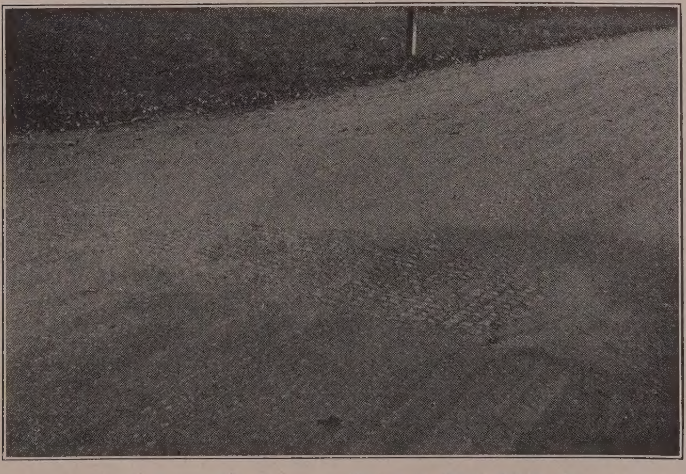


Fig. 1—Miscellaneous Cubes in Penfield Road

Surface dust swept off to show blocks. Photograph taken Oct. 6, 1913.

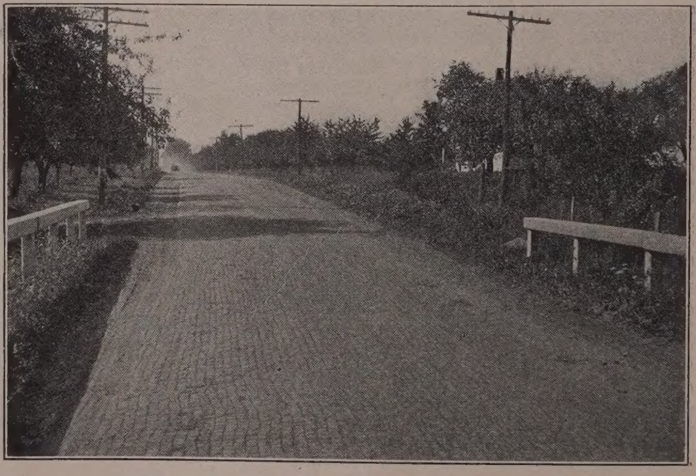


Fig. 2—Vitrified-Shale Cubes in Ridge Road

Laid by hand in 1909. Photograph taken Oct. 3, 1913.

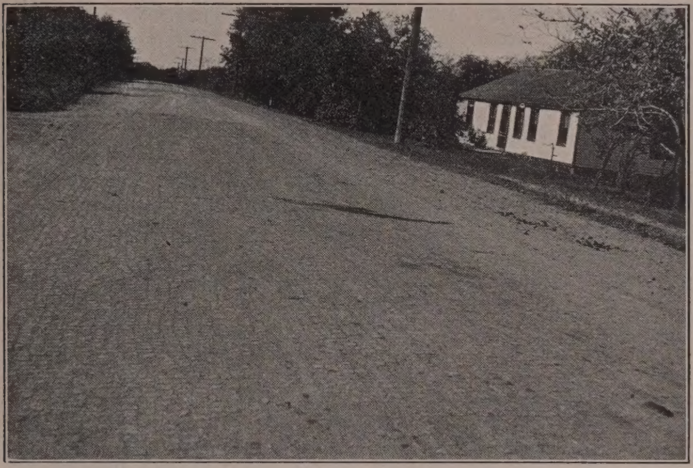


Fig. 3—Local Clay Ash Cubes in Ridge Road

Laid in 1910. Note shape and texture of surface. Photograph taken Oct. 3, 1913.

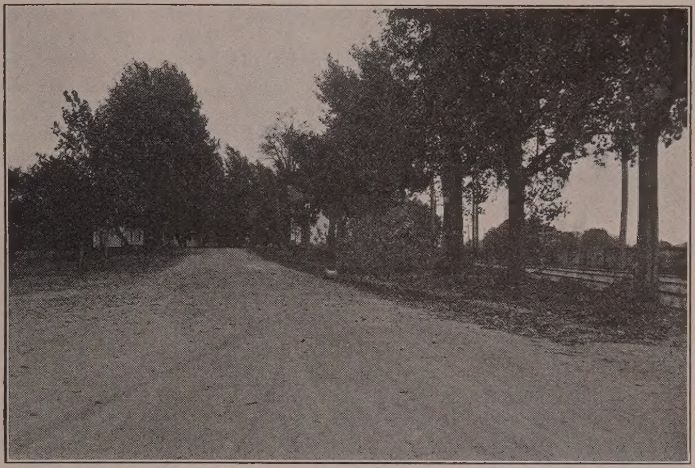


Fig. 4—Concrete Cubes Protected by Tarvia and Sand

Newport House Road laid in 1911. Tarvia applied in 1912. Photo Oct. 6, 1913

local clay-ash cubes were laid on the Ridge Road. The bulk of the concrete cubes was made in floor molds, using a very wet mixture. They were not as successful as the dry-mix machine cubes of the previous year, for they went to pieces completely in the spring of 1911. For some unknown reason they softened so badly that one could take a hoe and dig into them anywhere.

The clay-ash cubes were made by the Standard Sewer Pipe Company, of Rochester, in an effort to get a cheap local product that would stand the traffic. The cubes were naturally not as good as this method is capable of producing under further experiment. They did not appear to be nearly as good as the Reynoldsville vitrified-shale cubes of the previous year. The blocks from the first two kilns were laid without culling and without any attempt to separate the soft and hard burned cubes. The surface wore unevenly and became so rough that in 1913 a surface coating of bitumen and stone was necessary to keep it in usable condition.

The last kiln charge was separated carefully and the hard burned cubes laid together in one stretch. These cubes have shown up surprisingly well (see Fig. 3). Provided they had been laid with closer joints and tar filler, the wear would probably have been much less. It is evident that a local clay-ash cube can be produced which will withstand medium traffic if properly laid. The cost of this experimental piece was 99 cents per square yard in place, which would be materially reduced on large jobs.

In 1911 a mile of concrete-cube surface was laid on the Hudson Avenue Road in the town of Irondequoit. Having in mind the softening of the concrete cubes on the Ridge Road, Hercules waterproofing was used in the manufacture of some of the 1911 cubes. The gravel for the concrete was soft, containing a large percentage of weak sandstone. The cubes were laid on a foundation course of fine gravel.

The traffic on this road is extremely heavy and it was recognized at the time that the chances of success with this construction were not good. The road was a town road, the funds were limited and it was desired to keep as much of the money as possible in the town by utilizing the local material. The road failed in spots within a year, partly on account of the poor gravel foundation and partly by disintegration of the cube surface under the heavy traffic.

CONCRETE CUBES ON NEWPORT HOUSE ROAD

This same year the town of Irondequoit improved 1000 ft. of the Newport House Road, 12 ft. wide, surfacing with machine-made local gravel-concrete cubes. This is the only piece laid to date where the concrete cubes seem to be suitable for the conditions.

No road material except gravel is locally available and the improvement is a long distance from any railroad unloading point for imported material. The job was a town job where the funds were limited and it was considered advisable to spend the money for local materials. The gravel was obtained from a pit alongside the road and is a much better grade than that used for Hudson Avenue, but about the same as that in the Ridge Road cubes. The foundation course was 8 in. of local gravel, which was fairly coarse, but not as good as is specified for gravel bottom on State roads.

The traffic on this road is not large in volume, but the units are heavy. A 6-ton truck is used over it regularly. Having in mind the failure of the unprotected concrete cubes on the previous jobs, 500 ft. of these cubes were covered in 1912 with a surface coat of Tarvia A and screenings (see Fig. 4), and another 500 ft. with No. 4 road oil and sand. In 1912 400,000 more concrete cubes were made; these were placed in the spring of 1913 as an extension of the 1911 work. They were treated with a thin coat of No. 3 standard road oil to hold the filler in the joints (see Fig. 5).

The 1913 cubes are in perfect condition today. The 1911 cubes covered with road oil show some wear and incipient ruts in a few places, probably due to the failure of the foundation under the truck traffic. The 1911 cubes covered with Tarvia A are in good shape with the exception of a slight rut in one place. The tarvia surface coat has peeled in a number of places, though the surface had been cleaned with reasonable care before the application of the tar. It is evident, however, that such a surface coat will stick as well if not better than on the smooth surface of the standard concrete road. The experience with this road indicates that where the local road material is limited to a good gravel and where it is considered good policy to spend the road funds locally, or where the cubes are cheaper than imported stone macadam, the concrete cubes protected with a tarvia surface coat

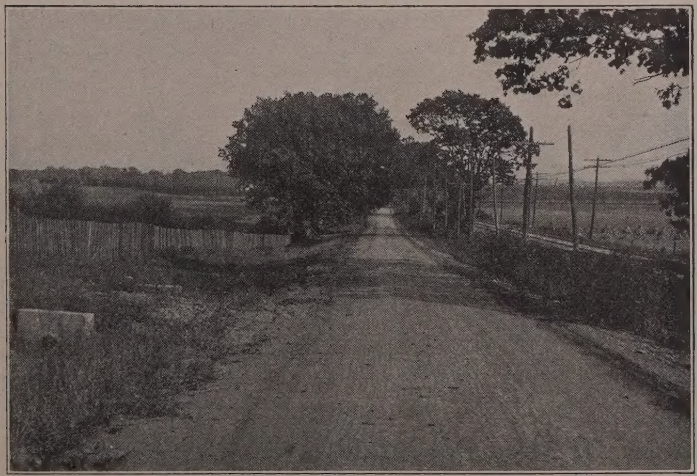


Fig. 5—Local Gravel-Concrete Cubes on Newport House Road

Oiled road laid in 1912. Photograph taken Oct. 3, 1913

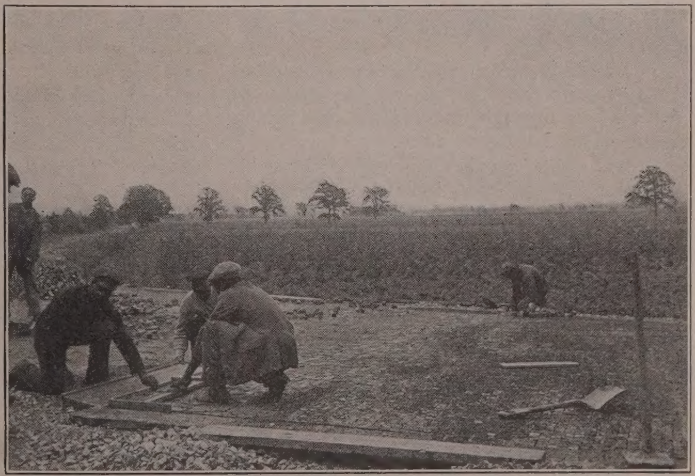


Fig. 6—Removing the Pallets Used in Laying Cubes

Each pallet holds 128 2-in. blocks.

make a satisfactory surface under a light volume of traffic.

In June, 1913, 220,000 2¼-in. vitrified-shale cubes made at Corry, Pa., were used to resurface a short stretch of the West Side Boulevard near the Rochester city line. The traffic on this section of the road is tremendous and the tarvia macadam required extensive repairs each season. The quality of the cubes is fairly good. The most interesting fact of their manufacture is that the makers succeeded in burning this order and 750,000 for the Ballantyne Bridge approach in a down-draft kiln containing two pockets holding 125,000 cubes apiece into which the cubes were shoveled like broken stone. This simplification of handling cut the cost of these first batches to $2.50 per thousand, or 55 cents per square yard, as against $3.20 and 71 cents for the Reynoldsville cubes in 1909. The freight was 11 cents per square yard, or a cost delivered of only 66 cents per square yard, as against 85 cents and 90 cents per square yard for ordinary paving brick. With the further reduction in cost that can be expected with a steady output vitrified-shale cubes are evidently an economical form.

The cubes were laid as follows: The uneven surface of the macadam base was trued up with Tarvia X and ¾-in. stone; sand ½ in. thick was used as a cushion and the cubes were laid by hand and finished as previously described, except that Tarvia B was spread in a thin layer over the surface to hold the joint filler in place and prevent excessive joint spalling. When the pavement was first completed the surface was not perfectly true in shape. This was due to insufficient care in truing up the base and sand cushion and to laying the cubes by hand instead of from pallets. The crown is also too great. A satisfactory crown for this type is from ⅜ in. to ½ in. per foot.

The condition of the cubes to-day is satisfactory as to wear, but I believe that the traffic is so heavy on this section that the only safe use of the cubes under these conditions is on a concrete base with grouted joints.

Conclusions

From a careful consideration of the work described the following facts stand out: The cube form of pavement is flexible under frost action, which makes it suitable as a surfacing on a macadam base. It is stable under traffic and shows no tendency to ravel or break down at the edges and can be successfully held there with a macadam or gravel shoulder without the formation of a rut, as is always encountered with concrete and stone edging used for brick. It gives a satisfactory surface in wet and dry weather and can be laid late in the season, requiring comparatively simple inspection.

The cube form can be successfully used as a patch with very simple manipulation. It reduces the tonnage and freight cost where imported material is required.

Gravel concrete cubes unprotected by a bituminous-surface coat have been complete failures under medium and heavy traffic; but if protected by a bituminous surface coat they serve satisfactorily under light traffic.

Vitrified-pipe clay cubes laid on concrete with grouted joints wear well under heavy auto traffic and medium team traffic.

Local clay-ash cubes laid on macadam base with sand joints show ability to withstand light traffic.

Vitrified-shale cubes laid on macadam base with wide sandy-loam joints show ability to stand medium traffic. When laid on macadam base with close joints filled with sandy or clay loam and oiled or tarred they show ability to stand heavy traffic. The indications are that a well-burned vitrified-shale cube laid on concrete foundation with grouted joints will stand satisfactorily the traffic on all but a few of the heaviest traffic country roads.

Concrete cubes at the present cost can compete economically in only a few cases with macadam. Vitrified-shale cubes at their present cost can compete economically with brick for the lighter travel brick roads and will probably be able to compete economically with bituminous macadam in many localities in the near future.

Convict Labor for Making Cubes

All executive road engineers are faced with the problem of reducing the cost, particularly the resurfacing cost, of the road systems. They naturally turn as a first resort to convict labor and are balked by the strong public sentiment against working prisoners on the roads. There is not this sentiment against working them in inclosures or at the State and county penitentiaries. The manufacture of some form of cube lends itself naturally to the utilization of convict labor under these conditions. The complete system of water and rail transportation in New York State makes it possible to ship within a short distance of most roads, and it would be possible to utilize this type at a tremendous saving over any of the standard pavements of to-day.

None of the cube pavements laid to date, except the small areas in the crosswalks, has been entirely successful, but the advance in their practical applicability has been so marked since 1908 that there is every reason for giving them a thorough trial.

Highway Improvements in North Alabama

Methods and Costs of Work, Organization of Field Forces and Studies of Plant for Hauling and Storing Crushed Stone

By P. S. FITZGERALD

Highway Engineer, Lawrence County, Alabama

THE winter and spring of 1911-12 were abnormally wet throughout the Tennessee River valley. In many sections the public roads became impassable; rural mail deliveries ceased for weeks at a time; farm products were temporarily worthless because of mud; alfalfa hay, commanding $35 per ton on board cars, was a grim joke in the fields and barns. But good-roads advocates at last had their inning. Defeated time and again at the polls in their previous efforts to secure authorization of bond issues, they seized this psychological moment, with the result that counties that had previously refused to issue bonds now lent enthusiastic support to the good-roads movement. Thus, born of desperation and nursed by the efforts of automobilists and other progressive citizens, the good-roads movement entered upon a remarkably rapid growth.

State Aid

Under a system of State aid to the counties, whereby each county may annually obtain certain funds for road construction from the State treasury by the appropriation of equal sums from the county treasury, many counties in Alabama have been led to construct, under State supervision, sample or model highways of the types most suited to their requirements, employing local materials. In the Tennessee valley good limestone and gravel are abundant, and several counties have chosen water-bound limestone macadam as the most economical and most serviceable type of permanent road surfacing within their limits.

So effective has been the object lesson and influence of the model roads built under State supervision that many counties have issued bonds for the construction of more roads, among them Lawrence County, an agricultural community of about 700 sq. miles in area and having a population of 25,000, crossed by 500 miles of many varieties of bad roads and 20 miles of railroad. The county has now been at work one year on macadam roads, with a county engineer in direct charge of the operation. Gradients are limited to 5 per cent and difficult ascents are satisfactorily accomplished at very moderate expense. The travel being relatively light, it was decided that, in general, 10 ft. of road metal 7 in. thick upon an 18-ft. road bed would be sufficient, and experience has approved this choice.

The most interesting phases of the work in Lawrence County consist, perhaps, not in the isolated instances of ingenuity or skill not applicable to ordinary working conditions but rather in the application and modification of widely used methods. The county has purchased and is operating two road-building plants consisting of two quarrying, crushing and screening outfits—one using steam power, the other gasoline—one internal combustion tractor, hauling reversible drop-bottom wagons, one traction-drawn machine, two 10-ton gasoline road rollers, and numerous smaller units.

Owing to the geological and topographical conditions, practically all of the quarries have been below the level of the crusher, necessitating hoisting the limestone to the crusher. Friction hoists attached to the driving gear of the crushers, pulling ¾-yd, end dump train cars on a 3-ft. track by means of ⅝-in. cable, have been employed. The simplicity and cheapness of this haulage are somewhat offset by the lack of two very vital essentials—mobility of track and provision for unit-basis work in the quarry. In small quarries, such as are the rule in road building, it is impossible to arrange tracks and allot cars so as to permit individual work on a fair basis of pay. It is believed that the use of a stiffleg derrick and suitable scale pans or boxes would provide the necessary mobility and allow each sledger to work by and for himself on a basis of an agreed price per unit of stone loaded in the scale pan.

Hauling with Tractor

The haul here is in most cases short; 2 miles are the maximum. The Rumely "Oil-Pull" tractor and Troy reversible wagons on long hauls reduce the cost of hauling to about 10 cents per yard-mile, compared with 25 to 35 cents per yard-mile with teams; although where three teams at $3 per day will haul all the stone crushed there is no economy in the tractor and reversibles. It costs little, however, to keep the hauling outfit in readiness, and its moral effect on the price of hired teams is very marked; for here, as everywhere, team owners charge "all the traffic will bear"—and generally strike for higher pay whenever the necessity for using them seems greatest.

The tractor used is small, pulling four 3-yd.

wagons, and frequently has made 100 yard-miles daily at an expense of less than $10, besides spreading and leveling the crushed stone with an ordinary road machine or grader attached to the rear of the train. Good teams haul 1½ cu. yd. per load, and if watched make ten to twelve round trips daily on a 1-mile haul. The limit of a day's work at macadamizing is the performance of the slowest machine in the chain from crushing to rolling. Thus far the county has found 1 mile in average weather a good month's work for one plant.

The subgrade is cut to the contour of the finished macadam with the road machine, pulled by the roller or teams, the earth being thrown out for shoulders. After the subgrade is rolled, from 4 to 5 in. of the coarsest stone are spread and rolled, followed by 2 to 3 in. of finer stone. Screenings are then spread evenly and carefully about 1 in. thick and the whole is thoroughly flushed with water and rolled to a finish. The shoulders are also shaped and rolled. If water is scarce and sand available, the finished surface is covered with about ½ in. of sand, which prevents raveling.

Organization of Field Force

The organization of the county forces for macadamizing is as shown below:

County Engineer

Foreman—Plant 1
- Driller.
- Hoister.
- Crusher feeders.
- Sledgers and loaders.
- Fireman.
- Tractor engineer (or teams).
- Roller man (road foreman).
- Spreaders.
- Sprinkler.

Foreman—Plant 2
- Driller.
- Hoister.
- Crusher feeders.
- Sledgers and loaders.
- Fireman.
- Roller man (road foreman).
- Teams.
- Spreaders.
- Sprinkler.

Daily report blanks are filled out with cost data by the foremen. The costs of the various parts of the work done to date are about as follows: Quarrying and crushing, 60 cents per cubic yard; hauling, 35 cents; subgrading, spreading, sprinkling and rolling, 30 cents, totalling $1.25 per cubic yard of loose stone, which runs between 1200 and 1300 cu. yd. per mile. The costs named do not include interest, depreciation and plant, nor engineering and general supervision.

There are two other plants at work in the county under contract, at $1.75 and $2 per cubic yard respectively, with maximum hauls of 2 and 4 miles. Portions of the grading are being done by contractors and portions by day forces, as necessity and expediency have dictated. At this stage of the work average costs are apt to be misleading, but it is thought that, omitting plant, interest, depreciation, engineering and supervision, the average cost, including grading, rights-of-way, quarry sites, small bridges and culverts, and macadamizing, will approximate $3000 per mile.

Studying the costs of the different parts of the macadamizing in the light of a single day's performance reveals the fact that the subgrading, spreading, sprinkling and rolling cost could be reduced probably 35 per cent, or to 20 cents per cubic yard, by providing sufficient stone to occupy the roller full time. In order to provide sufficient crushed stone, the crushing and quarrying plants should be enlarged or so arranged as to maintain maximum output during bad as well as good weather. Ground storage and reloading devices would aid.

It is the practice now to screen the crushed stone into requisite sizes in separate compartments of the bin, which usually holds from 5 to 40 cu. yd., and to discharge by gravity into wagons. If for any reason the bins become full, either the crusher is stopped or the crushed stone drawn out and stored on the ground, whence it is reloaded by hand at additional expense. It would seem that if, instead of bins, stock piles were arranged and the sized stone taken by conveyors from small hoppers immediately under each screen section and conveyed and dumped automatically to the proper stock pile and afterward loaded as needed by means of some mechanical loading device—steam-shovel, clamshell, or coal-wagon loader—the problem would be solved.

Conveyors require little additional power and may be rigged to the screen drive. Once long enough to carry to the extreme point of delivery the intermediate space may be stocked back as far as the screen if necessary. The conveyors may be very close to the screen, so as to give the stock pile considerable height. If, for instance, it were necessary to provide for four months' stocking (7000 cu. yd.) and the height of the screen, as in these plants, were 25 ft. above ground, and three sizes of the usual proportions were wanted, the stock piles would be planned to hold about 4000 cu. yd. of No. 1 stone, 2000 cu. yd. of No. 2 stone and 1000 cu. yd. of No. 3 stone. These piles could be 20 ft. high and 50 ft. wide at the base and 250 ft., 125 ft. and 65 ft. long respectively, if on practically level ground. The entire surface area covered would be about ½ acre, the clearing and grubbing and rolling of which, if necessary, should not cost more than $100, or about 1½ cents per cubic yard of stone stocked. If the piles were higher—as could be easily arranged by placing the screen higher—the stock piles would require less ground space.

Loading into Wagons

The cost of loading into wagons need not be more than 5 cents per cubic yard, using some mechanical loading device. The cost of conveyors would probably not exceed the cost of bins, and the only additional plant required is the loading device. Variations in the arrangement of the hood and screen as to the direction from the crusher are also feasible.

The objections to the stock-pile system are additional plant cost for loading devices and possible adverse conditions of quarry surroundings. The advantages are continuous operation of plant, reserve of crushed stone for emergencies, maximum speed of each part of the work without dependence on the other operations and employment for the men all the time desired.

While at the present time the science of building permanent highways in the United States occupies the brains and energies of only a few of the engineers and contractors of the country, the movement for better roads is rapidly assuming such vast proportions that it is a matter of a short time only when the work will, of necessity, be handled on a larger scale and by larger interests and in larger units. It, therefore, behooves engineers, contractors, and machinery manufacturers alike to give to the subject of methods, costs and machinery the closest study and investigation. The genius of American industrial supremacy lies in the constant and tireless effort for greater efficiency, larger output and lower costs.

The Flood Loss due to the overflow in the Ohio valley last March has been estimated by the U. S. Weather Bureau at $163,000,000. To prospective crops alone are credited $11,000,000, and injury to railroad, telegraph and telephone lines and to farms and farm property a very large amount.

Year's Progress at Panama

Pictorial Record of Final Stages of Work and Completed Structures

The insert sheet accompanying this issue contains eight pictures taken along the line of the Panama Canal. There are two remarkable photographs of blasts—one at the Cucaracha Slide and the other at the Gamboa Dike. Others show the locks at Gatun, the spillway at Miraflores, and the condition of the excavation at critical points in the canal prism. These photographs were intended to accompany the annual report of Col. George W. Goethals, published in the Engineering Record last week, but were delayed in transmission from the Isthmus.

Sand-Clay Road Maintenance in North and South Carolina

Abstract of Address Delivered by Leonard Tufts before Third American Road Congress at Detroit

In North and South Carolina my assistant, Mr. McQueen, and myself have charge of the maintenance of 250 miles of gravel and sand-clay roads. The surfacing costs $300 per mile, the maintenance $30 per mile. I know of several gravel roads the expense of surfacing which has been about $1,500 and of maintenance, $150 per mile. The low price of labor and the convenience of material have much to do with these moderate figures.

Dirt roads, to be satisfactory, must receive attention every day in the year, but this constant care is inexpensive. The majority of people do not consider the sand-clay top, soil, gravel and other dirt roads good simply because they are not maintained.

There are now in Mineral Springs township between 40 and 50 miles of roads the tax for which is 25 cents on $100, which raises only about $2,000 a year, indicating a poor, sparsely settled district.

Two men with a pair of mules are given a section of road varying in length from 20 to 30 miles. They keep the gutters clean, keep the bushes cut back, haul surfacing material where it is necessary, and drag the roads in the section where they happen to be after a rain. Each of the farmers who have two or more horses is given a road drag, which costs us about $2.50. We select one man to attend to the dragging of every 8 miles. Every time a man drags he sends in a bill to my office and receives a check for the amount of labor for his team and himself. In some sections we are quite successful in getting men to drag at the proper time, and in other sections we find considerable difficulty, but we are gradually getting more and more men to look out for this work.

Changes in the Missouri River are so rapid that a stranger can hardly realize them. For instance, at a point near Kickapoo ferry landing, where there was a maximum downstream current of about 7 miles an hour and an upstream current of about 2 miles, the sandy bottom shifted so fast that in two days a shoal 600 ft. long and 2 ft. out of water was cut away and the depth of water increased to 6 ft. In another place water shoaled 12 ft. in three days. At some points shoals formed in a very few minutes, and in the same time the current would change from 4 miles downstream to 2 miles upstream.

Typical Section of Bituminous Test Pavement on Byberry and Bensalem Turnpike

Experimental Pavement in Philadelphia

Test Section 3.4 Miles Long Composed of Short Stretches of Different Types of Surfacing

A SERVICE test road 3.4 miles long, on the Byberry and Bensalem turnpike, leading north out of Philadelphia, was completed during the past season by the Bureau of Highways and Street Cleaning of Philadelphia. The road was laid in 26 sections, most of which are from 250 ft. to 600 ft. in length. The first section, however, has a length of 3700 ft. The 18015 ft. over which the pavement is constructed are divided as follows: Bituminous surface on a broken stone base, 8400 ft.; vitrified block on a 4-in. concrete base, 2305 ft.; bituminous surface on a 5-in. concrete base, 1650 ft.; Hassam, 550 ft.; a special type known as Bicomac, 550 ft.; and 4560 ft. which were resurfaced with a bituminous mixture by the penetration method.

The description of the composition of the various sections, as furnished by Mr. William H. Connell, chief of the Bureau of Highways and Street Cleaning, follows:

Section 1. Station 0 + 00 to 37 + 00; bituminous pavement known as Amiesite. The mineral aggregate of crushed trap rock passing a 1½-in. screen was treated with a liquefier and then mixed with asphaltic cement heated to 275 deg., after which oxide of lime was added. The paving mixture consisted of the following proportions: Mineral aggregate, 92 per cent; asphaltic cement, 5 per cent; lime, 1½ per cent; liquefier, 1½ per cent. The pavement was laid on a broken stone base and was 2 in. thick after rolling.

Section 2. Station 37 + 00 to 47 + 00; bituminous pavement laid in accordance with the so-called Topeka specifications. The mineral aggregate consisted of trap rock chips, screenings and sand, used in the proportions of approximately three parts of trap rock chips and screenings to one of sand. The finished pavement contains 10 per cent of bitumen and was laid on a broken stone base to a thickness of 2 in. after rolling.

From Station 42 + 00 to 47 + 00 a seal coat of 1/3 gal. per square yard of Pioneer road surface asphalt was applied and covered with clean ⅜-in. trap rock chips and rolled.

Section 3. Station 47 + 00 to 50 + 00; 5-in. concrete base, mixed in the proportions of 1 : 3 : 6, with bituminous top consisting of an application of ½ gal. of Pioneer road surface asphalt per square yard, covered immediately with a thin layer of trap rock chips passing a ⅜-in. screen and rolled.

Section 4. Station 50 + 00 to 52 + 50; vitrified block pavement on a 4-in. concrete foundation.

Section 5. Station 52 + 50 to 59 + 50; 5-in. concrete base, mixed in the proportion of 1 : 3 : 6, with ¼-in. contraction joints, at 40-ft. intervals, filled with asphaltic cement of a penetration of about 90. The section is divided into three divisions, each covered with a bituminous top, as follows:

Station 52 + 50 to 54 + 58. After cleaning the surface of the concrete 1/6 gal. per square yard of Ugite "A" was spread; then ⅜ gal. per square yard of Ugite No. 3 was applied at a temperature of 280 deg. and immediately covered with ¼-in. dry trap rock chips, after which another application of ¼ gal. per square yard of Ugite No. 3 was applied, which in turn was covered with Torpedo sand and rolled.

Station 54 + 58 to 57 + 17; ¼ gal. per square yard of Tarvia "B" was applied, after which ⅜ gal. per square yard of Tarvia "A" was applied at a temperature of 250 deg. and covered with Torpedo sand.

Station 57 + 17 to 59 + 50; ⅛ gal. per square yard of Texaco asphalt, cut back with naphtha, was applied, after which 3/5 gal. per square yard of Texaco asphalt (55 penetration) was applied and covered with clean ¾-in. trap rock chips and rolled. Texaco asphalt, 3/5 gal. per square yard, was then applied and covered with clean ¾-in. trap rock chips and rolled.

Section 6. Station 59 + 50 to 72 + 00; bituminous pavement, known as Filbertine, proportioned as follows: ¾-in. stone, 55 to 65 per cent; sand, coarse to fine, 35 to 45 per cent; asphaltic cement, 70 to 80 penetration, 6.6 per cent. The pavement was laid on a broken stone base and was 2 in. thick after rolling.

Section 7. Station 72 + 00 to 84 + 50; the paving mixture consists of a mineral aggregate of 2 parts trap rock passing a 1¼-in. screen; one part asphalt paving sand; 5 per cent of mineral dust, and 5.2 per cent of bitumen. The pavement was laid on a broken stone base and was 2 in. thick after rolling. From Station 72 + 00 to 78 + 00 a seal coat of ¼ gal. per square yard of asphalt was applied and covered with ⅜-in. trap rock chips, and rolled.

Section 8. Station 84 + 50 to 87 + 50; vitrified block pavement on a 4-in. concrete foundation.

Section 9. Station 87 + 50 to 94 + 00; 5-in. concrete base, in the proportions of 1 : 3 : 6, with contraction joints at 40-ft. intervals, filled with asphaltic cement with a penetration of about 90. The section is divided into four divisions, each covered with a bituminous top, as follows:

Station 87 + 50 to 90 + 00. Two-fifths gallon per square yard of Dolarway bitumen was applied at a temperature of 270 deg. and covered with Torpedo sand.

Station 90 + 00 to 90 + 70. One-eighth gallon per square yard of Bicomac was spread on the surface of the concrete pavement and then a mixture of trap rock chips, trap rock dust and Bicomac was applied and rolled with a hand roller. One-half of this surface was covered with trap rock dust and the other half was covered with trap rock chips and rolled lightly.

Station 90 + 70 to 91 + 35; 2/5 gal. per square yard of asphalt, cut back with naphtha, was spread upon the surface of the concrete and the naphtha burned out. Trap rock chips were then spread and rolled.

Station 91 + 35 to 92 + 00; ⅛ gal. per square yard of Bicomac was applied to the surface of the concrete pavement, after which 2/5 gal. per square yard of asphalt (100 penetration) was applied at a temperature of 400 deg. and covered with clean trap rock chips and rolled.

Section 10. Station 94 + 00 to 97 + 00; vitrified block pavement on a 4-in. concrete foundation.

Section 11. Station 97 + 00 to 103 + 00; bituminous pavement. The paving mixture consists of mineral aggregate crusher run trap rock passing a 1-in. screen and retained on a ¼-in. screen; bitumen, 4.8 per cent. The pavement was laid on a broken stone base and was 2 in. thick after rolling.

Section 12. Station 103 + 00 to 109 + 00; bituminous pavement, having a mineral aggregate composed of run of bank gravel containing no stone over 1 in. in greatest dimension, and sand. The gravel was sound, hard-grained and free from loam and clay. The sand was clean, hard-grained and moderately sharp, and of such size that all passed a 50-mesh sieve, and not more than 5 per cent passed a 200-mesh sieve, and not less than 20 per cent passed an 80-mesh sieve. The paving mixture contained a sufficient quantity of this sand to give a dense mineral aggregate. To this was added 8.1 per cent of bitumen. The pavement was laid on a broken stone base and was 2 in. thick after rolling.

Section 13. Station 109 + 00 to 112 + 50; vitrified block pavement on a 4-in. concrete base.

Section 14. Station 112 + 50 to 118 + 00; 5-in. Hassam pavement with a bituminous top.

Section 15. Station 118 + 00 to 121 + 00; vitrified block pavement on a 4-in. concrete base.

Section 16. Station 121 + 00 to 127 + 00; resurfaced by penetration method, using Ugite binder.

Section 17. Station 127 + 00 to 130 + 60; resurfaced by penetration method, using Byerlite asphalt.

Section 18. Station 130 + 60 to 133 + 00; vitrified block pavement on a 4-in. concrete base.

Section 19. Station 133 + 00 to 139 + 00; resurfaced by penetration method, using Tarvia X binder.

Section 20. Station 139 + 00 to 145 + 00; resurfaced by penetration method, using Texas road surface asphalt.

Section 21. Station 145 + 00 to 151 + 00; resurfaced by the penetration method, using Standard Binder B.

Section 22. Station 151 + 00 to 157 + 00; resurfaced by the penetration method, using Pioneer Road Surface asphalt, Binder B.

Section 23. Station 157 + 00 to 163 + 00; resurfaced by the penetration method, using Bermudez asphalt, Binder B.

Section 24. Station 163 + 00 to 169 + 00; resurfaced by the penetration method, using Sun Hydrolene Asphalt Binder.

Section 25. Station 169 + 00 to 174 + 50; Bicomac pavement, consisting of a 4-in. 1 : 3 : 6 concrete base with wearing surface constructed as follows: Concrete base, after being placed and while still wet and in a plastic condition, was covered with a resilient concrete wearing surface 1 in. thick after compression. Wearing surface, consisting of 1 part Portland cement, 6 parts clean sand or crusher dust, 12 parts clean stone and 8 per cent Headley Good Roads Company's No. 26 was applied cold. The stone was free from dust and contained not more than 25 per cent of 1½-in. size; the balance was ¾-in. stone and dustless screenings of like grading. Bitumen was so prepared that it would mix with water in any proportion. This compound, known as Bicomac, was used in the proportions of 70 per cent. Bicomac and 30 per cent water. The mineral aggregate was thoroughly coated with the solution, the sand and cement being mixed together and added to the coated stone and the whole thoroughly saturated with the solution, laid, and rolled.

Section 26. Station 174 + 50 to 180 + 15; vitrified block pavement on a 4-in. concrete foundation.

Description of Foundation Course for Bituminous Pavements

All bituminous pavements built by the mixing method were laid on a broken stone foundation, prepared by thoroughly cleaning, spiking up and shaping the old surface, then adding sufficient 1½-in. trap rock to give it the required contour and a thickness of not less than 4 in. on top of the old foundation, after rolling. After the material for the first course had been properly shaped and rolled dry trap rock screenings were spread and thoroughly rolled, with as little water as possible, until well bonded. This course was filled not quite flush, but left with the coarse stones projecting slightly to furnish a better surface on which to put the wearing course.

All bituminous broken stone pavements laid by the penetration method (Sections 16, 17, 19, 20, 21, 22, 23 and 24) were laid on a broken stone foundation, prepared in a manner similar to that for the mixed pavements, with the following exceptions: The 1½-in. stone was laid to a depth of not less than 3 in. over the old foundation and, after being shaped and rolled, was covered with trap rock screenings to fill the voids. The surface was then rolled dry, sprinkled with water and rolled again. Upon this was spread a course of 1½-in. trap rock, passing a 2⅜-in. screen and being retained on a ¾-in. screen, which was rolled to a depth of 3 in. Upon this the bituminous binder specified was spread at the rate of not less than 1¼ nor more than 1½ gal. per square yard.

After the application of the bituminous binder enough ¾-in. dry trap rock, free from dust, was spread to just fill the voids and cover the surface, after which the road was thoroughly rolled until the surface was bonded. The surface was then swept and from ⅓ to ½ gal. per square yard of bituminous binder applied. This in turn was covered immediately with a thin layer of dry trap rock chips, free from dust, and then rolled.

Electrification of the Chicago, Milwaukee & St. Paul

Notes on Plan to Substitute Electricity for Steam in Operating over the Heavy Grades in the Rocky Mountains

Before Jan. 1, probably, the Chicago, Milwaukee & St. Paul Railway will have reached a decision as to the type of equipment to be employed for the extensive main-line electrification of its railroad over the mountains in Montana. It is practically certain that the overhead trolley system will be adopted, using either the 14,000-volt, 25-cycle, alternating-current system or the 2400-volt direct-current system. Plans submitted by the General Electric Company and the Westinghouse Electric & Manufacturing Company are now under consideration. For the railroad company the entire matter of electrification has been placed in the hands of Mr. C. A. Goodnow, vice-president in charge of operation and construction.

At first it is proposed to electrify a division 113 miles long, extending over the Rocky Mountains between Three Forks and Deer Lodge, Mont. This work will be begun early in 1914. Ultimately the electrification will be extended to that portion of the main line between Harlowton, Mont., and Avery, Idaho, a distance of 440 miles. This work will cost the railroad $6,000,000 or $8,000,000, and the electrical construction work will proceed at the rate of about $1,500,000 or $2,000,000 annually. This program is believed to foreshadow the electrification of the entire line from Harlowton to the Pacific Coast, including the line to Tacoma, a main-line distance of 865 miles.

Power Supply

Electrical energy will be obtained from the Montana Power Company, of Butte, Mont., and the Thompson Falls Power Company, with which the railroad company has entered into long-term contracts. The energy will be obtained from hydroelectric plants and will probably be delivered at seven points between Avery and Harlowton, the standard transmission being 110,000 volts at 60 cycles. At Great Falls, Mont., on the Missouri River, where there are already in existence two other generating plants, one of 40,000 hp and one of 15,000 hp, a new hydroelectric plant with an ultimate rating of 100,000 hp is now under construction. Energy will also be taken from two hydroelectric plants on the Missouri River at Helena, a generating station on the Madison River about 30 miles from the railroad at Three Forks, and a new plant now building at Thompson Falls, on Clark's Fork, which is one of the affluents of the Columbia River. The length of transmission will vary from about 15 to about 140 miles.

Profile

In the zone of the proposed electrification the railroad crosses three separate mountain ranges—the Bitter Root Mountains, the Rocky Mountains and the Belt Mountains—all within the territory known as the Continental Divide. The elevations attained by the railroad are respectively 4170 ft., 6322 ft. and 5788 ft. above sea level. The gradients range from 1 to 2 per cent. in the mountains, with many miles of from 0.3 to 0.6 per cent. grade between the ranges.

Across the ragged profile presented it is proposed to haul all passenger trains at speeds of from 25 to 30 miles per hour and freight trains at from 15 to 18 miles per hour. All switching service will also be performed by electric locomotives. A single electric freight locomotive will be capable of hauling a train as heavy as 2500 tons on 1 per cent grades, and two of them will handle the same tonnage on 2 per cent grades. The electric locomotive units will consist of two duplicate parts coupled together. Less trouble is expected on the 2 per cent grades than on the 1 per cent grades, for there are stretches of the latter 50 miles or more in length, and rigorous shop tests will be necessary to demonstrate that the motors will not overheat on these long pulls.

Storage Reservoirs for Power Plants

Near the headwaters of the Madison River (which is an affluent of the Missouri) a storage reservoir covering an area of many miles has been constructed. By this means sufficient water will be impounded to furnish the generating stations at Madison Canyon, Helena and Great Falls during the months of late summer and during the winter. Thompson Falls, on Clark's Fork, will be protected by Flathead Lake, a large natural body of water. It is felt that ample provision has been made for a sufficient supply of electrical energy to operate the railroad under all conditions.

A feature of the electrification in connection with train dispatching is pointed out by Mr. Goodnow. At the outset only 20,000 kilowatt-hours will be available for railroad operation under the contract. The dispatcher will have this amount of energy to move his traffic, and he must not use electricity in excess of that amount. To this end he not only must have the entire situation clearly before him so that trains will not be started from terminals at hours when they will be unreasonably delayed on the line waiting for energy, but he must supervise the speed of the trains, since the speed on ascending gradients represents exactly the electrical energy used. In order to push an important train across a mountain range at maximum speed it may be necessary for the dispatcher to slow down other trains, or he may order one or more trains to move at maximum speed to provide for the prompt movement of subsequent trains.

Expected Advantages

Experience with heavy railroad operation in and near New York City shows that electric locomotives can be run 2000 miles without inspection under the conditions existing there. It seems probable, therefore, that the locomotives which will be placed in service on the mountain divisions of the Chicago, Milwaukee & St. Paul can be relied upon to make from 250 to 300 miles at the outset. As there will be no delays for coaling, taking on water, cleaning fires or waiting for steam, it is expected that the tonnage will be handled with fewer locomotives, higher average speed and a regularity which will result in better operating conditions both to the patron and to the employees of the road. Passengers will be able to enjoy the mountain scenery without the annoyances incident to steam locomotion. Another point of interest is that while the steam locomotive is at its worst in freezing weather, the electric locomotive is at its best at that time, since practically the only difficulty experienced with the electric locomotive is to prevent the motors from heating when doing maximum work.

One of the important benefits to result from electrical operation is the braking of trains descending mountain grades by reversing the motors on the electric locomotives, making the use of the airbrake, except in cases of emergency, unnecessary. One advantage of this method of braking is the elimination of danger of derailment from broken wheels due to overheating from the pressure of brake-shoes on long descending grades.

Bow River Bridge on the Banff-Windermere Motor Road—Castle Mountain in Background

Banff-Windermere Motor Road

Automobile Highway, with Light Grades and Easy, Superelevated Curves, Built through Wholly Unsettled Country in Rocky Mountains

A HIGHWAY built specially for travel by motorcar through 100 miles of wholly unsettled country and over a route chosen with primary regard for scenic beauty—these are the features of the Banff-Windermere road now nearing completion in the Rocky Mountains of Alberta and British Columbia, just south of the main line of the Canadian Pacific Railway. The project has received widespread attention because of the demand by the large number of visitors who annually spend their holidays in the tourist resorts between Banff and Field for a first-class motor highway linking these points together and extending about 65 miles in a southwesterly direction through two ranges of the Rockies to the Windermere valley, which is assuming importance as a tourist center. There is also an interest in the road from economic and engineering viewpoints in the study of the expenditure upon it in relation to its possible usefulness to the masses, and because it is, perhaps, the most picturesque and most difficult portion of the trans-Canadian motor highway. In addition to scenic attractions the new road shortens the distance from Banff to the Windermere district from 170 to 103 miles and makes readily accessible a region only slightly known and in no way developed. Considerable sums have been spent by the Canadian Pacific Railway in improving the trails and roads in the Rocky Mountain Park, as it is believed that the successful handling of large numbers of tourists in a mountainous country is not possible unless access to surrounding territory is easy to the majority of such visitors. The railroad company was therefore willing to contribute to the cost of the Banff-Windermere road, and joint financial backing was arranged between the Dominion and Provincial Governments and the Canadian Pacific Railway.

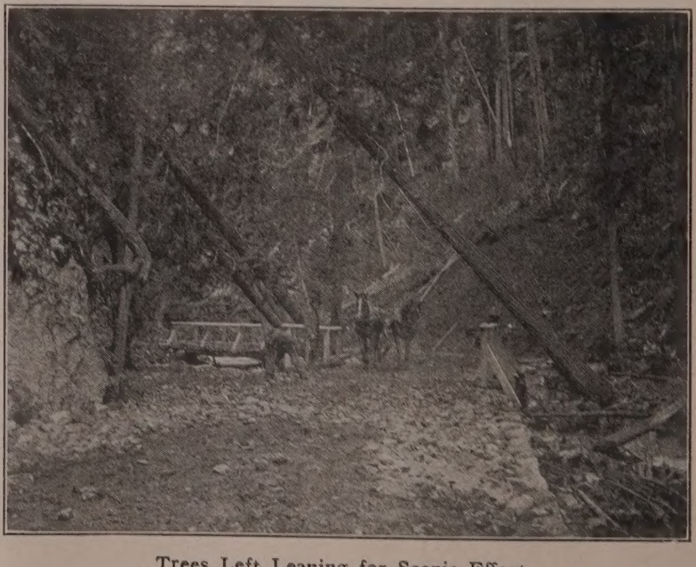
CHOICE OF ROUTES

Locating engineers were first in the field in 1910 and, after running lines over several alternative routes, selected one which crossed Sinclair and Vermillion passes, at elevations of 4860 and 5264 ft. respectively. The elevation at Banff is 4500 ft. The choice was based on a consideration of lowest grades, best scenic advantages, and least cost of construction and maintenance. On account of the low elevation of the two passes named the road will be open later in the fall, it was reported, and earlier in the spring than any other route examined.

When the surveys were first begun the instructions were to limit the maximum grade to 10 per cent. After the location of the entire line it was found that for the most part a 5-per cent maximum grade was quite feasible (with the exception of 1500 ft. of 9-per cent grade through the Sinclair canyon) and the few exceptions could, at some later date, be reduced to the 5-per cent limit at no very great additional cost. The maximum gradient is not continued for any great length anywhere on the line. In fact, after crossing the British Columbia boundary line going south, there is an almost continuous coast down a 2-per cent grade for nearly 50 miles, with only one or two short reverse grades. Care has been taken to provide momentum stretches in the approach to maximum grades to permit the speeding up of motors to attain the greatest climbing power.

From Banff to Windermere the new route divides itself naturally into four divisions of unequal length. The first, an 18-mile stretch from Banff to Castle, was located and partially constructed in 1912. The second natural division, 11 miles long, reaches from Castle to the British Columbia boundary line, and was located late in 1912. Five preliminary lines were run out before an entirely satisfactory route was secured. Both these sections of the new road lie in the Banff Park and were paid for wholly by the Dominion Government. It is estimated that when completed the total cost of the road within the park limits will be $50,000. The money appropriated thus far has

Cleared Right-of-Way in Heavy Green Timber



Trees Left Leaning for Scenic Effect

been used in clearing and grading, the idea being to spend available money in first getting the road in such shape that it would be useful for reaching those sections further on. To complete the work within the park limits it will be necessary to widen, drain, metal and surface the road as it now stands. It is expected that the final appropriations will be made next season, and if so, the road can be made ready for service within a few months.

The section of the road between the boundary line and Sinclair is 62 miles long and is being financed jointly by the Province of British Columbia and the Canadian Pacific Railroad. The surveys were completed in 1911 and construction was started in 1912. During the present season the work is being carried on by a full force of about 150 men working from three camps. The estimated total cost of the work in British Columbia is placed at $210,000, and the road is expected to be ready for service late in 1914.

From Sinclair to Windermere, a distance of 12 miles, the route is over the old "Golden Road," which will be improved and included as a part of the through highway.

Clearing

On all parts of the line practically the same specifications have been followed. In heavy green timber the cleared width was 33 ft., with the exception of curves, where a considerably greater width was required. In burnt standing timber and deadfall specifications called for a cleared width of at least 66 ft. On the Castle-Boundary Line section the route was practically all in timber, about half being through heavy deadfall, the remainder being in heavy green timber. The cost of clearing here varied from $25 per acre, where the work was light, to $197 per acre in the heaviest timber traversed. The corresponding grubbing costs ranged from $4 to $5 per 100 ft. station, the grubbing usually being done for a width of 20 ft. In the cost of clearing is included "trimming up" such of the felled timber as was useful for culverts, bridge or crib work, large quantities of such timber being reserved from the burning and piled along the edge of the clearing. Great care was exercised in burning because of the certainty that if once beyond control the fires would cause very serious and extensive destruction of surrounding timber, so valuable to the scenic effect. Day and night watchmen were provided for each fire, and so far no forest fires have started.

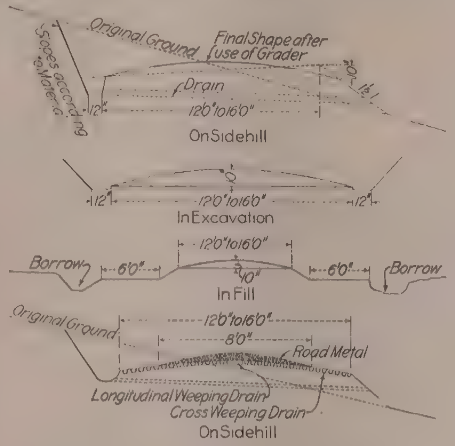
Although specifications were drawn up under which contracts could be let, it was decided to do all of the work by day labor under the supervision of the engineers. The specified width of roadway in the park is 16 ft. on tangents, widened to 20 ft. on curves, and all bridges and culverts are put in accordingly; but due to the desirability of getting a partially completed road over the line with the funds at hand, the width has, in some places, been left at 12 ft. until more money is available. Outside the park limits a width of 12 ft., widened to 18 ft. on curves, has been made standard. The accompanying drawing shows the cross section of the road as being constructed, the crown requiring to be rolled with a 5-ton roller before the metal is placed, and the surfacing metal to have a thickness of 6 in. at the crown and 4 in. at the sides.

The cost of surfacing, including rolling, is said to average about 50 cents per square yard. The table of elevations used for outer edge of the road on curves is given in the next column.

The only bridge required which could not be constructed from materials at hand was that across the Bow River near Castle. In this case the length of span and the nearness to the railroad made a steel bridge preferable, and accordingly two 90-ft. riveted-steel pony trusses were erected, figured to carry a 10-ton road roller. The trusses were supported on concrete abutments and center pier, all based on piles. The cost of the completed bridge was $10,767.52. This figure would have been lower, it is reported, were it not for the fact that appropriations were insufficient to complete the work from the camp first established. High water caused delay and made pier falsework expensive, and extreme cold weather held back concrete and steelwork. During the erection of the superstructure the mercury went as low as 40 below zero.

ELEVATIONS USED FOR OUTER EDGE OF CURVES

Deg. of curve	Elev. in ft.	Deg. of curve	Elev. in ft.
1	0.50	6	1.00
2	0.60	7	1.10
3	0.70	8	1.20
4	0.80	9	1.30
5	0.90	10	1.40



Banff-Windermere Road Sections

One of the difficult features of construction is the fact that throughout the entire length of the line there is not a single base of supplies or a settlement of any kind where provisions could be secured in emergencies. It was first planned to take advantage of the ease with which trails can be cleared over deep snow and bring in equipment and camp supplies by sleigh in winter, storing these in caches at convenient points along the line. However, owing to delay in appropriations and other causes, practically all supplies went in by pack train at first and later by wagon. The equipment and most of the supplies were started overland from the railroad on the north, but some of the light equipment and provisions for use on the southern end of the road were sent in from Windermere.

The average gross cost per mile of the completed road, including preliminary surveys and engineering supervision, but exclusive of the Sinclair-Windermere section, is estimated to be $3500 per mile.

The preliminary surveys, the designing of all structures and the general supervision of construction have been under the direction of Haffner & Wurtele, of Vancouver, B. C.

ABOUT 600,000 HP will be developed in Norway by English capital, according to a grant of the Norwegian Storting to the Nitrogen Products & Carbide Company, Ltd., of London. The capitalization of the company is $9,650,000, and its director is chairman of the Alby United Carbide Factories, which at Odde, Norway, has the largest carbide factory in the world.

Dynamometer Wagon for Road-Resistance Tests

Measuring Tractive Effort on Post Roads and Pull Required for Moving Street Cleaning Apparatus

Comparison of two applications of the traction dynamometer operated by the U. S. Office of Public Roads is made possible through the inauguration on Nov. 20 of a series of tests on the apparatus of the street-cleaning department in Washington, D. C., the first of their kind ever made. The dynamometer wagon was designed in 1906 in the engineering division of the Kansas State Agricultural College, under the direction of Dean E. B. McCormick, now head of the testing laboratory of the U. S. Office of Public Roads. In its original position the dynamometer proper, consisting of two carefully calibrated coil springs controlling a recording stylus through a set of gears, was suspended from the bed of a Studebaker truck midway between the axles. The pull was transmitted by the wagon tongue directly to the dynamometer, which was anchored by a steel rod to the rear axle. The pull, or draft, is measured by the compression of the coil springs, which communicate through the gears to a brass point, which graphically registers on sensitized paper operated by friction rolls over a flat platen. These friction rolls are run by chain gears from the rear axle. A stationary needle records a straight line on the paper, representing a draft of 500 lb. The truck is provided with eight sets of wheels with steel tires ranging from 1⅝ in. to 6 in. in width. The machine is propelled by horses at an easy walk; the question of speed, therefore does not enter into calculation, as in the car used in railroad practice.

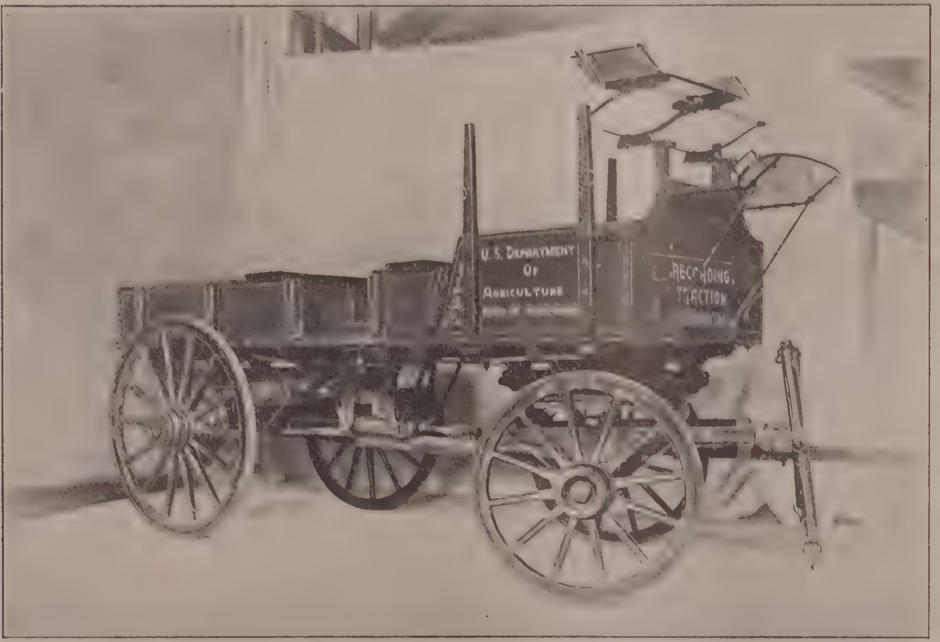
Tractive Resistance of Post Roads

The most important use to which the apparatus in its original position has been put since the United States Government assumed joint ownership with the Kansas State Agricultural College in 1908 is the testing of about 230 miles of post roads during the summer of 1913. Thus far the Office of Public Roads has made twenty-six inspections of designated roads, covering 1,143.11 miles, of which 358.6 miles have been accepted as coming under the provisions of the law.

The purpose of the tests was to ascertain (a) the increase in the territory which could be served by each carrier as a result of improvement, (b) the possible increase in the number of delivery days in each year, and (c) the relative saving to the Government. The wagon was driven over six routes, registering the total traction of each. The roads so tested (using the name and the approximate length) are as follows: Ames, Iowa, 30 miles; Florence, Ala., 35 miles; Greenwood, Miss., 30 miles; Mankato, Minn., 76 miles, including distances through incorporated towns; Rockville, Md., 10 miles; and Zanesville, Ohio, 50 miles. All except the last mentioned are at present natural roads—earth, sand, sand-clay or gravel. The Zanesville section is part of an old national highway, which is of brick in some places. In an effort to represent the prevailing style of traffic different widths of tires were used at Ames, Florence and Greenwood. The traction of these roads will again be recorded when the United States engineers have completed the improvements, the purpose of the test being to determine the resulting diminution of tractive resistance. In the office the areas within the 500-lb. pull line and the path taken by the brass stylus are measured with roller planimeters; the average draft for any section is then computed. The complete results of these tests are not yet available for publication.

The series of tests instituted Nov. 20 in Washington were intended to determine (a) the draft required to operate squeegees, carts, sprinklers, power flushers, etc., on various pavements, (b) the effect of gearing of various kinds on the draft required, (c) the effect of the diameter of the wheel, and (d) the difference in draft, if any, between wagons in which front and rear wheels track and those in which they do not. Each test covered a route of about 5 miles, starting from the stable at Thirteenth Street and Pennsylvania Avenue, S. E., the types of pavement traversed being sheet asphalt, asphalt block, and granite block. There were several heavy grades on the test route.

To permit the dynamometer wagon to measure the traction of the street-cleaning machines it was necessary to turn the dynamometer itself end for end. It was fixed to the front axle and the free end was attached to the tongue of the machine to be tested.



Traction Dynamometer Used by U. S. Office of Public Roads

The tests showed that the recording apparatus was very sensitive. The initial point of an uphill grade was at once recorded on the moving sheet, as were such details as street-car tracks and broken places in the road.

The graphic path of a machine being drawn over asphalt presented a smooth appearance compared with that of the same machine drawn over asphalt block or granite block. Furthermore, the uniformity of this registered line decreased for the heavier vehicles traveling at slow speeds, for the machine holds back between successive efforts; thus a series of impacts resulted from the necessity of overcoming initial friction oftener than in the case of a lighter wagon.

On a down grade the recording apparatus showed that the lighter machine took no pull at all for any style of pavement, whereas in the case of the heavy vehicles on the block pavements the little jolts and starts would indicate their resistance in a jagged line.

At the end of the route each machine was weighed on a large scale. In the case of the large squeegees the weight was taken full and empty. On the afternoon of Nov. 21 one of these squeegees was taken over the route. The representative character of the test was indicated on a steep hill of asphalt block. The machine was driven up one block of the hill empty. It was then taken to the foot of the hill, filled with water and again drawn up the same block with the total load of water which was flushed on the street.

Notes were carefully kept during the progress of the test, recording the beginning of every grade, every corner that was turned and every curb, as well as incidental obstacles.

The tests were performed by members of the Office of Public Roads and employees of the Washington Street Cleaning Department under the supervision of Mr. McCormick and Mr. J. W. Paxton, superintendent of the street-cleaning bureau.

Safety in Tunneling

Means of preventing accidents in driving tunnels, levels and drifts for mining or water development purposes are discussed in Miners' Circular 13, prepared for the U. S. Bureau of Mines by David W. Brunton and John A. Davis. Beginning with the statement that for sixteen representative mining and water tunnels there were 4.7 deaths and sixteen serious accidents annually per 1000 men employed, the authors' address suggestions to the superintendent, foreman and miner.

The fact that the greatest source of danger is from falls of rock is made the basis for an appeal for uniform systems of supporting roofs. The danger may also be lessened by avoiding overcharging shot holes.

"Sounding" a roof is not the proper way of determining its safety; in many cases experienced men have been deceived by the apparent solidity indicated by this practice.

Workmen should not smoke near explosives nor carry loose detonators in the clothing or in the same package with dynamite. Explosives should be kept near dry (not hot) places never directly over steam or hot-water pipes or other heated metal surface. Frozen dynamite should never be placed directly in hot water or in steam. The burning rates of different brands of fuse should be frequently determined in the interest of economy as well as safety. Thirty minutes is given as the minimum interval within which one may investigate a misfire.

Work of Philadelphia Bureau of Highways during 1913

Statement of Progress and Cost of Construction by Contract and City Forces

According to a detailed progress statement supplied by Mr. W. H. Connell, chief of the Bureau of Highways and Street Cleaning of Philadelphia, $6,353,857.38 was expended between Jan. 1 and Dec. 1, 1913. Of this amount $5,831,107 was disbursed on contract work, including $1,566,300 distributed over eight street cleaning contracts, and $522,750.38 is chargeable to the municipal forces. Asphalt repairs totalled $342,745.64; $179,217.63 was spent for granite-block repairs by the forces, at an average cost of 39.5 cents per square yard.

The tabulated record follows:

FINANCIAL STATEMENT AND AMOUNT OF WORK—JAN. 1 TO DEC. 1, 1913

Character of work	No. of contracts	Miles	Amount
Grading	138	26.925	$680,169
Asphalt paving	98	10.710	510,205
Vitrified block paving	28	3.370	173,741
Granite block paving	5	1.146	41,700
Asphalt repaving	27	3.053	102,100
Wood block repaving	29	2.206	131,900
Vit. block repaving	19	2.790	123,000
Gran. block repaving	9	1.457	100,300
Asphalt resurfacing	57	7.042	252,292
Vit. blk. resurfacing	5	0.341	10,481
W. B. mac. resurfacing Bit. mac. resurfacing	26	16.555	191,970
W. B. mac. surfacing	14	6.550	84,150
N. E. Boulevard	1	5.5	1,000,000
S. Broad St. Boulevard	1	1.15	210,000
Asphalt repairs	3	...	330,805
Maintenance of bridges	5	...	46.490
Collection of garbage	1	...	229,300
Street cleaning	8	...	1,566.300
Miscellaneous contracts	11	...	46,204
Totals	485	88.795	$5,831,107
Work by municipal forces:			
Macadam repairing and resurfacing, 274.877 square yards, or macadam roads put in first-class condition amounting to		27.0	114,443.59
Total miles of all classes o. street work completed and in progress to Oct. 15th, 1913		115.795	

Other work by municipal forces:	Square yards	Amount
Granite block repairs	453,763	$179,217.63
Brick repairs	96,169	31,738.39
Granolithic repairs	2,961	3,104.42
Cobble and rubble repairs	3,189	1,092.82
Patching with tarvia	5,512	3,734.31
Bituminous surface treatments (20.68 miles)	...	18,081.76
Cleaning, shaping up dirt roads, gutters, cleaning macadam roads, and sprinkling	...	81,211.51
Miscellaneous work	...	13,683.02
Asphalt repairs	14,887	11,940.64
Repairing and paving gutters	22,230	11,361.00
Repairs to bridges	...	23,467.09
Repairs to sewers	...	29,674.20
Total work by municipal forces		$522,750.38
Grand total		$6,353,857.38

Rapid-Transit Construction in New York City

According to the report of Mr. Alfred Craven, chief engineer of the Public Service Commission for the First District, New York, construction work for the dual system rapid transit contract is now under way on twenty-six sections under contracts aggregating $86,371,000 and employing 6649 men. Construction is in progress in all of the boroughs except that of Richmond, and includes 47 miles of new subway and elevated lines operated by the New York Municipal Railway Corporation and by the Interboro Rapid Transit Company in nearly equal amounts. Within the last few days bids have been taken for about $2,000,000 worth of elevated railroad construction, besides which an extension of about 1000 ft. of elevated construction is to be made on the Myrtle Avenue line, Brooklyn. The Flatbush Avenue station of the Fulton Street elevated railroad is to be reconstructed.

Concrete Mixing Plant and Rock Barge in Operation

Building Piers 30 and 32 at San Francisco

Methods of Casting Concrete Piers in the Dry within Steel Cylindrical Caissons Driven into the Bottom of the Bay

RAPID construction of docks in San Francisco Bay, made necessary by reason of the early date at which the Panama Canal, with its expected impetus to water traffic, is to be opened, has impelled the contractors having the work in hand to use new methods and perfect old ones in their efforts to meet the time-requirement clauses. A general outline of the present harbor work was given on page 49 in the Engineering Record of July 12. Other articles, descriptive of various features of construction, of the development of the Holmes concrete-protected wooden pile, and of the Koetitz concrete pile cast inside of a large open steel caisson, have been printed in issues of June 22, 1907, March 21, 1908, Aug. 28, 1909, July 16, 1910, and Aug. 6, 1910.

Four docks now under construction are nearing completion and all have been constructed by the open-cylinder method. The largest single contract is for piers 30 and 32, already leased by the state to the American-Hawaiian Steamship Company, which wished the sheds to be of timber construction so that in case of fire the débris could be cleared away quickly. The piers are 720 and 807 ft. long respectively, and each is 200 ft. wide. For storage purposes a portion of the space between the two piers is covered, making the whole structure of U shape, with the dimension on the inner side of the legs 555 ft. The two piers contain 1512 concrete piles approximately 70 ft. long and from 3 to 4 ft. in diameter, resting on a sand and clay bottom. The piers are spaced from 15 to 18 ft. apart, the closer spacing being used on account of superstructure spans. A monolithic slab-and-girder reinforced-concrete floor ties the tops of the piers together. The contract involves 2800 tons of steel, 55,000 cu. yd. of concrete and about 1,000,000 ft. of lumber.

Pier Casting

By the improved method of casting the piers in the dry, an 8 or 9-ft. steel cylinder, with ¾-in. plates riveted together with butt straps on the outside, is lowered and driven into hardpan or other suitable foundation. The material is then excavated with ¾ or 1-yd. Hayward orange-peel buckets. Most of the water is removed later in about twenty-five minutes by 700-gal. cylindrical buckets having trap doors hinged on a rod through the diameter, a line running to the second drum on the hoisting engine being attached to each flap to spill the water as soon as the bucket has been raised and swung clear of the caisson. The last of the water is removed by a steam jet suspended by a block attached to a small outrigger on the main leads. If tightly sealed, men enter the caisson and excavate a smooth bed for the footing. The latter is cast in a 6-ft. length of wood-stave pipe, varying, for different parts of the pier, from 5 to 7½ ft. in diameter. The concrete, however, is not placed until the wood-stave-pipe form, with the reinforcing steel in it, has been lowered into place. This form extends into the footing form for 1 ft., so that the wet concrete will not spill over the edges of the lower form into the space between it and the caisson. In the latter event, pulling the caisson would be difficult, if at all possible, without injuring the pile. Concrete is so dumped into place through jointed pipe as to protect the man at the bottom, whose duty it is to distribute and tamp the concrete behind the reinforcing steel. After setting at least twenty-four hours the caisson is pulled, but the wood-stave form is left for the teredo and limnoria, which will eat through to the concrete in about six months. In fact forms left in the water three months have burst when filled with concrete, and temporary falsework on which the contractor's equipment rests is said to be giving him apprehension lest destruction take place before the work is completed, so rapidly do these pests perform.

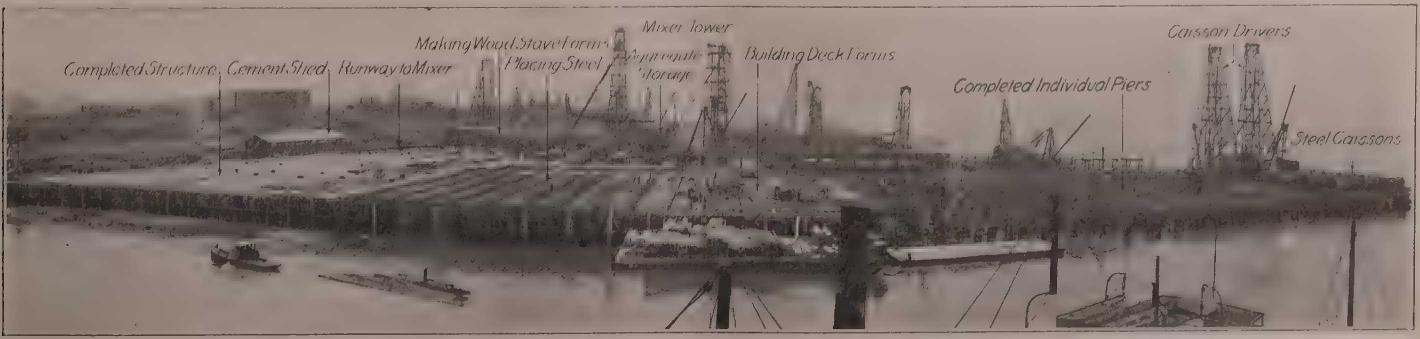
Bracing the Caissons

When sunk into place the bases of the cylinders are found to be stationary, but a flowing of the mud off shore often makes the tops incline. The force of this pull in some instances has been sufficient to snap a ⅝-in. cable by which the caissons were held in place. It is now the practice to pour concrete as soon as possible after driving. A slight inshore inclination is also given, that is, the tops of those cylinders most affected near the outer ends of the dock were driven about 7 in. out of plumb, but by the time the concrete was poured they would be about vertical. To keep the pier itself from shifting, it is anchored to its fellows before the caisson has been entirely removed from over it. A 3 x 8-in. strut is placed between adjacent piers. Three strands of No. 6 wire are passed around the piers and made taut by twisting, but temporarily, or while the caisson is still ready to be dropped back, in case of sudden tipping, 3 x 8-in. planks are nailed to the wood-stave casings—one each side of the struts as tension members.

In bracing the caisson a single strut is placed against an adjacent pier already poured and a ½-in. cable passed around the piers at each side. Long turnbuckles of ¾-in. rods facilitate bringing the cables taut.

For a very few piers it has been found impossible to seal the bottom of the caisson, fresh water being struck occasionally. In this case the excavation is carried on as usual and when the approximate depth required has been reached the pile-driver hammer is lowered to make a smooth bottom. A footing form with a floor of two layers of 2-in. plank is then suspended above water in the leads with the pier form above it, a ¾-in. wire rope being used as a bail for the footing form. Concrete must then be hoisted to the top of the form so as to allow setting out of water. Sometimes nests of piles, 15 to 20 ft. long, are driven in the bottom of the caissons and a concrete seal of 2 to 3 ft. depth placed under water.

Making the wood-stave pipe is carried out



Panoramic View of One of the Piers, Showing Various Stages of the Work, with Completed Portion on Left in half-circle forms of 1½-in. pipe secured to timbers spaced about 4 ft. apart. Full circles are used inside for the top staves. A strap is passed around the pipe, allowing the half-circle form to be depressed so the completed pipe may be rolled along the skids after the ¾-in. bands have been cinched up, using Allen clips. Fabrication of the reinforcing steel, comprising 1-in. corrugated bars, spaced about 10 in. apart and wound with ¼-in. rounds placed 12 in. apart, takes place at one end of the pipes and when completed the cage is pulled into the pipe by a small hoisting engine.

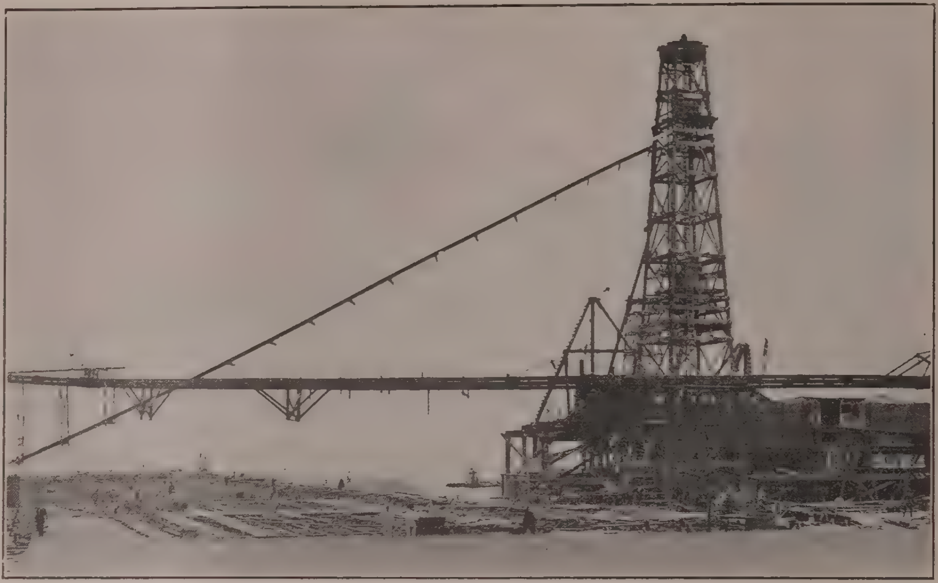
At the ends and center of the pipe the steel is secured and spaced by wiring to the staves at four points around the circle. As the concrete is filled in these wires are cut.

CONCRETE PLANT

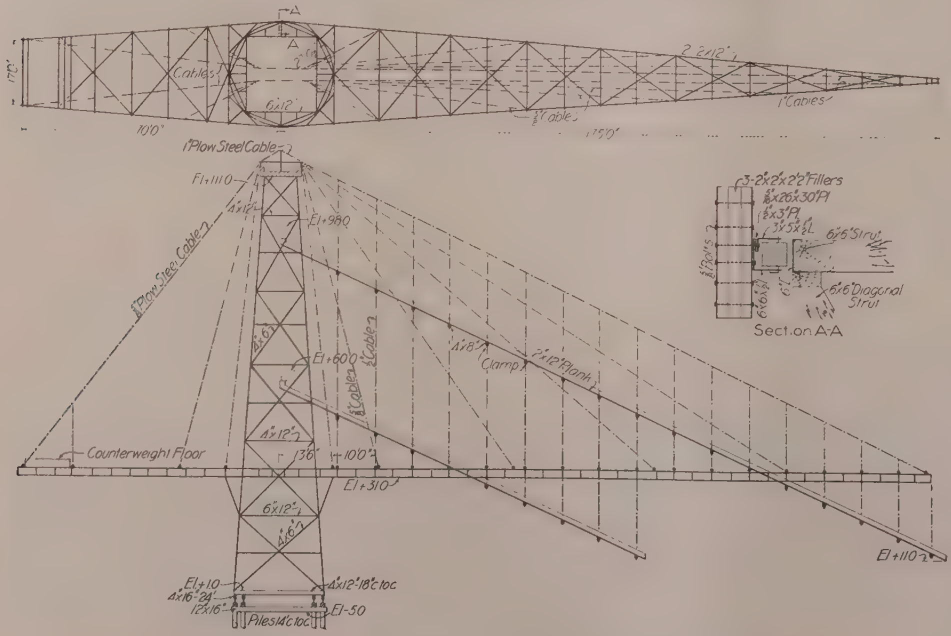
A revolving boom, 175 ft. long, carrying at its base a 1-yd. Dasher concrete mixer delivering into a 1-yd. elevating bucket, has a central tower 110 ft. high. The whole equipment is mounted on four tracks over falsework paralleling the bulkhead line inside of the material bunkers. The general outline is shown in the drawing herewith. It was found cheaper, on account of the thin slab and the resultant small amount of concrete that could be placed directly, to wheel the material to place in Sterling, Champion or Dasher 6-cu. ft. buggies from the end of the lower V-shaped spout shown and from another built below it. To facilitate loading, a small hopper was placed on the end of the spout..

The material bunkers were filled from the water side by sub-contract with the San Pablo Quarry Company, which used a floating mechanical equipment comprising eight hoppers of 500-cu. yd. total capacity over a belt conveyor leading to a boot of a bucket elevator discharging by an open spout, about 25 ft. long, into the bunkers. This elevator is pivoted at the boot, permitting a movement of 90 deg. The broken stone was obtained from quarries across the bay or near San Quentin.

Sand was recovered from scows by a service derrick, using a clamshell bucket. Storage was provided for 500 yd. of rock and 300 yd. of sand. Between these hoppers was a space to receive cement over an incline from cars on the Belt Line tracks. Koppel cars carrying twenty-five sacks of cement each were hauled up the incline by a 10-hp motor by means of a ⅜-in. cable. Apportionment of the 1 : 2 : 4 mix was accomplished under the storage bunkers, where 42-cu. ft. side-dump industrial cars were loaded up to a certain mark with stone, four sacks of cement were added, and the remaining space was filled with sand. The cars were then pushed by hand until they were over the hopper of the mixer. Two or three cars served each mixer.



Concrete Plant with 110-Foot Tower and 175-Foot Revolving Boom



Structural Details of Concrete Tower with Revolving Boom

Large equipment used by the contractor comprised one floating driver with 118-ft. leads mounted on a 40 x 110-ft. scow made from one-half of an old ferryboat; four 20 x 50-ft. scows with shorter leads used for excavating and placing material; one 90-ft. driver, working from the falsework on the wharf near the sea wall; a general service derrick with 50-ft. boom, and a small barge on which was mounted a 10 x 10 x 10-in. Laidlaw-Dunn-Gordon steam-driven air compressor furnishing air to a Little Giant power drill used to bore the timber in the fender and trusses in the shed.

Soon after constructing the tallest driver it was found necessary to lengthen it by 5 ft. To raise the material, a 12 x 12-in. boom 30 ft. long was bolted to one of the leads so as to extend upward for one-half its length. Two pine sticks, 3 ft. square, were set on top of the old headblock of two pairs of 12 x 12-in. iron bark sticks separated by an 8-in. pine filler, to support a new one consisting of two 16 x 18-in. sticks of iron bark cut from rudder stock. The six-sheave block, with ⅞-in. yellow strand wire rope, was transferred to the space between the two headblocks, holes being bored in the lower one for the rope. To clamp the headblocks together, four 1¼-in. bolts were passed through 8-in. channels and 1-in. plates.

The Pacific-Wakefield Company has the contract for docks 30 and 32. Mr. Jerome Newman, chief engineer, has charge of all dock work for the Harbor Commission. Messrs. Carl Uhlig and Frank G. White are assistant engineers and Mr. H. M. Kebby is chief inspector.

Some Data on Earth Excavation

By E. W. ROBINSON,

Engineer with McKenzie-Williams Construction Company

The following data were obtained on some excavation done by the McKenzie-Williams Construction Company while preparing to construct a reinforced-concrete subway to carry a street under several railroad tracks in Memphis, Tenn., during the fall and winter of 1912 and 1913. The work was interrupted considerably by rain and freezing weather, which undoubtedly added to the cost, especially as the soil was a sticky, spongy red and blue clay. The earth was loosened with a plow and shoveled into wagons with slat bottoms and hauled, on an average, 1700 ft. to the dump. The rate of wages for labor was from 15 to 20 cents and for teams from 42½ to 50 cents per hour. The actual cost on 10,976 cu. yd., solid measurement, was 22.3 cents for loosening and shoveling into wagons and 28.5 cents for hauling, or a total of 50.8 cents per cubic yard. The cost per cubic yard-mile for hauling was 88 cents.

To get an idea of the per cent of increase in volume for this kind of soil, an accurate record of the number of loads hauled, together with the sizes of the loads, was kept. The following figures give this information with a fair degree of accuracy:

Total loads hauled	14,901
Total cu. yd., solid measurement	15,876
Average cu. yd., solid measurement, per load	1.065
Average cu. yd., loose measurement, per load	1.368
Increase or swell, cu. yd., per load	0.368
Per cent increase	28.45

Composition Flooring

Comparison of Its Most Important Characteristics with Those of Eighteen Other Materials in General Use

THE lack of standardized tests for floor-surfacing materials lends interest to the conclusions presented by Mr. H. M. Hooker, district manager of the Marbleoid Company, of Pittsburgh, in an address before the Engineers' Society of Western Pennsylvania. Basing his opinions upon a two years' investigation of synthetic surfacing, both in the United States and in Europe, Mr. Hooker chose eighteen qualities upon which to rate nineteen types of flooring, giving what he considered a just appraisal of the relative importance of each quality. The results reached have been incorporated in the accompanying table, which is supplemented by an abstract of the address.

CHARACTERISTICS AND COSTS

Cleanliness.—Composition flooring is laid plastic in one or two coats and sets in a monolithic mass. When ribbons and borders are employed these are inserted before the set is complete. Where base and wainscot are used these are ordinarily run into the flooring material with a cove so that the finished work has a smooth, jointless surface, which can be freely mopped, scrubbed and cleaned, and which offers no refuge for filth and germs.

Quietness.—In quietness composition flooring ranks high, four only of the materials normally used surpassing it, cork, rubber, linoleum and carpeting.

Abrasion.—The dust of abrasion creates a serious objection to the use of many materials in many locations. It damages the things upon which it falls; it is distinctly unhealthy; it accompanies the destruction of the flooring from which it is abraded. Toughness is almost always the antitoxin. Composition flooring possesses this quality in a high degree, and it has a relatively high immunity from abrasion, ranking therein with linoleum at the head of all flooring materials.

Resilience.—Fatigue in material and traveler are largely coincident. Resilience is the most pleasing feature under the tread that a floor can possess. For places where people are forced to stand for hours at a stretch it is a cash asset. Composition flooring here ranks high. Cork tile, linoleum, rubber tile (when new) and white pine possess somewhat more resilience and owe much of their flooring value to this fact. Yet cork tile, linoleum and rubber tile are slightly more tiring because owing to their softness they offer more frictional resistance to the foot or truck wheel passing above.

Slipperiness.—Terrazzo and glazed tile are always slippery. Concrete, when clean or untreated, is comparatively immune from this objection. When the surface pores of concrete are filled by the application of waterproofing filler, however, it also becomes slippery. Composition flooring is immune from slipperiness under all conditions, ranking with cork, linoleum and marble.

Appearance.—Composition flooring is now surpassed in appearance by six standard materials. The rating is based upon single-color composition work. The appearance of some of the work now installed and of many laboratory products indicates that the best work a few years hence will take rank very close to the top of the scale.

Degree Waterpoof.—Two factors play their part in determining the waterproof value of a flooring—first, the absorptive character of the material itself, and, second, the joints or seams which, as usually installed, it offers to the passage of liquids. Composition flooring is practically non-absorbent, its co-efficient of absorption after forty-eight hours' immersion being less than 2 per cent. Under constant immersion there is a gradual softening of the regular commercial composition which disqualifies it for swimming tanks and for conditions of permanent wetness. If the material is intermittently dried there is no deterioration, so that it may be successfully used for very wet places where the moisture is applied at intervals. Its jointless feature gives it a great advantage when compared with tile and marble. Terrazzo and concrete would be equally jointless were it not that owing to their brittleness cracks almost always occur during uneven settlement.

Plasticity.—Every building settles more or less unevenly and becomes a warped structure. In some buildings also there is pronounced vibration and bending of the flooring under loads. If the flooring is sufficiently flexible it will adapt itself to the new condition without visible effect; if not, cracks appear in the floor. Linoleum, cork tile, rubber tile and wood are ideal in this regard; terrazzo, clay tile and stone, on the other hand, have but little give. Composition flooring will never crack under normal settlement warping, though cracks occasionally appear when the settlement is extreme.

Warmth.—Next to cork, composition flooring is the warmest flooring material in standard use. It is therefore particularly useful where it is desirable to retard heat transference. An examination of the table brings out clearly its thermal value as contrasted with marble, tile, terrazzo and certain other materials now extensively used.

Life.—The life of composition flooring when properly installed is undetermined. Material suitably installed six or eight years ago shows no appreciable deterioration. It will doubtless be good for 100 years, and will certainly outlive the usefulness of the building in which it is installed, except in the rare instances of certain monumental buildings.

Degree Fireproof.—Composition flooring is fireproof. It may be heated to a temperature of 1700 deg. Fahr., chilled in water, reheated, chilled and heated again, and will not be destroyed. It will stand temperatures in excess of those usually found in burning buildings and is much above the fireproof requirements of city building codes and fire-insurance companies. Among fireproof flooring materials it is unique in its possession of softness, warmth and comfort under the foot.

Elasticity.—Rubber tiling, when new, has a pleasant elasticity under the tread. Linoleum has the same virtue. Composition strikes the middle ground between ceramic and rubber tiling.

Crushing Strength.—Because for many purposes the crushing strength of a building material is of vital significance, as in the case of a foundation or understructure, it has become customary to apply tests for this to flooring materials. In this respect composition flooring ranks midway between tile and concrete.

Structural Strength.—In structural strength composition flooring ranks fifth among the nineteen standard materials used. It is always a strengthening unit integral with its foundation; it stiffens the building's frame.

Acid Resistance.—Almost any concentrated acid will attack composition flooring. In those unusual conditions where strong acids reach the floor surface, as in certain chemical plants, tile or paving brick should be used. These instances are infrequent, as it is generally important only that a flooring material be practically unharmed by occasional contact with dilute solutions. Composition flooring meets this requirement.

Alkali Resistance.—The material is practically alkaliproof for normal use. It may be freely washed with gold dust, pearline, soap and the usual lye compounds and washing powders. Nevertheless, alkali has some effect on composition flooring.

COST TABLE AND RANK IN PER CENT OF NINETEEN FLOOR MATERIALS WITH RESPECT TO EIGHTEEN IMPORTANT PROPERTIES

Type of flooring	Price per sq. ft. 1000 sq. ft.	Price per sq. ft. 10,000 sq. ft.	Cleanliness, 96*	Quietness, 79	Resistance to abrasion, 79	Resilience, 77	Immunity from slipperiness, 72	Appearance, 70	Waterproof quality, 62	Plasticity, 60	Warmth, 57	Life, 56	Fireproof quality, 42	Elasticity, 33	Crushing strength, 13	Rupture, 13	Acid-proof quality, 12	Alkali-proof quality, 12	Immunity from expansion, 5	Lightness, 1	Average†
Composition flooring	$0.33	$0.25	100	75	100	90	100	80	90	50	98	70	100	50	40	30	10	10	70	53	82
Cork tile	.85	.75	40	100	95	100	100	85	25	95	100	50	0	70	2	3	30	80	98	100	72
Linoleum	.12	.10	70	96	100	100	100	75	50	100	—	5	0	100	2	0	25	0	90	71	70
Oak	—	—	35	50	95	90	50	95	25	95	90	50	0	90	15	56	33	90	100	81	63
Maple	.18	.16	35	50	95	90	50	90	25	95	90	50	0	90	14	60	30	90	96	83	63
White pine	—	—	32	60	90	95	60	60	25	95	90	45	0	90	7	66	30	80	98	94	62
Yellow pine	—	—	—	60	88	90	60	40	25	94	90	40	0	80	9	100	30	80	98	83	59
Asphalt	.25	.15	70	75	95	40	100	0	100	30	60	5	0	60	9	1	50	50	0	32	54
Marble	1.25	1.00	85	6	20	3	100	100	90	3	5	100	100	3	100	20	30	95	45	6	52
Rubber tile	.60	.50	0	98	30	95	100	80	0	100	90	0	0	100	0	0	0	10	0	32	49
Slate	.50	.45	60	6	20	3	99	40	95	3	5	99	100	3	74	20	40	95	32	0	45
Clay tile	.60	.50	75	5	40	4	30	85	90	4	0	100	100	5	50	25	100	100	50	20	43
Terrazzo	.40	.35	90	0	40	3	0	80	100	1	5	95	100	3	30	4	50	100	0	30	43
Mosaic tile	.60	.50	75	5	40	4	0	85	90	4	0	100	100	5	40	4	100	100	50	30	42
Portland Cmt. Concr.	.08	.06	90	5	10	1	70	45	100	1	5	90	100	1	30	5	50	70	0	32	42
Limestone	—	—	50	6	12	3	98	20	90	3	5	98	100	3	74	20	30	95	45	6	40
Paving brick	—	—	50	5	30	4	30	30	10	4	0	100	100	5	79	8	100	100	54	16	33
Face brick	—	—	25	7	5	1	90	40	5	1	8	70	100	1	47	7	90	95	56	27	30
Common brick	—	—	6	10	0	0	100	0	0	0	10	60	100	0	31	6	80	95	56	32	25

*The relative weight in point of importance immediately follows each property. †The average does not apply to cost.

Lightness.—Composition flooring is the lightest of the fireproof materials. It weighs slightly more than wood, but much less than concrete.

Cost—The unit cost of composition flooring is usually between 20 and 50 cents per square foot. When laid in a considerable area the price is about one-fourth that of marble, one-half that of good tile, and two-thirds that of terrazzo. It is about one and one-half times the price of a wood floor when on a wood foundation. On a concrete foundation the costs of wood and composition flooring are about the same, as the latter can generally be set off against the cost of wood sleepers, cinder-concrete fill between sleepers and the hardwood finish.

Composition flooring may be laid upon wood, concrete, iron or steel foundations. It cannot be laid directly upon plaster, plaster board, brick or terra cotta. It may be laid upon new or old wood floors. The flooring should be well-seasoned, not more than 6 in. wide nor less than ⅞ in. thick, securely face-nailed to each under beam and where possible laid rough side up. It must not sag under the load for which the floor is intended. The best practice is to apply expanded metal lath, about 27 gage, or similar reinforcement, on all wooden foundations.

Concrete Foundations

When of concrete the foundation should be of a fairly rich mixture composed of Portland cement, clean, sharp sand and an aggregate of steam cinders, gravel or broken stone in a proportion not weaker than 1:3:5. It is important that the mortar which flushes to and near the surface under tamping be not less than 1:3. Otherwise, while the composition will adhere firmly to it, there is danger of cleavage in the concrete just below its plane of contact with the composition. A rough wood float finish is desirable. The concrete should be thoroughly set and dry before the composition is applied.

Iron and steel foundations should be rough finished and unpainted.

The materials to be used in the case of any high-grade floor are prepared at a factory and delivered to the job in two units, the magnesium chloride and the dry mixture. The magnesium chloride is furnished either in concentrated solution or as a solid salt. In either case enough water is added to bring it down to the proper strength, 21 to 22 deg. Beaumé, where the temperature at the place of installation is around 70 deg. Fahr. The dry mixture is a mixture of all other ingredients.

Conclusions

Composition flooring is the issue of scientific effort to incorporate in a flooring the physical characteristics most to be desired for any given conditions. It is a light-weight, fireproof, resilient covering. It is laid plastic, about ½ in. thick, and sets in a few hours into a seamless, tough, warm and fairly quiet mass. It is laid over wood, metal or concrete, and adheres firmly thereto. Practically every one who has given it careful study is convinced that it will soon be generally recognized and extensively used as one of the valuable building assets of the world.

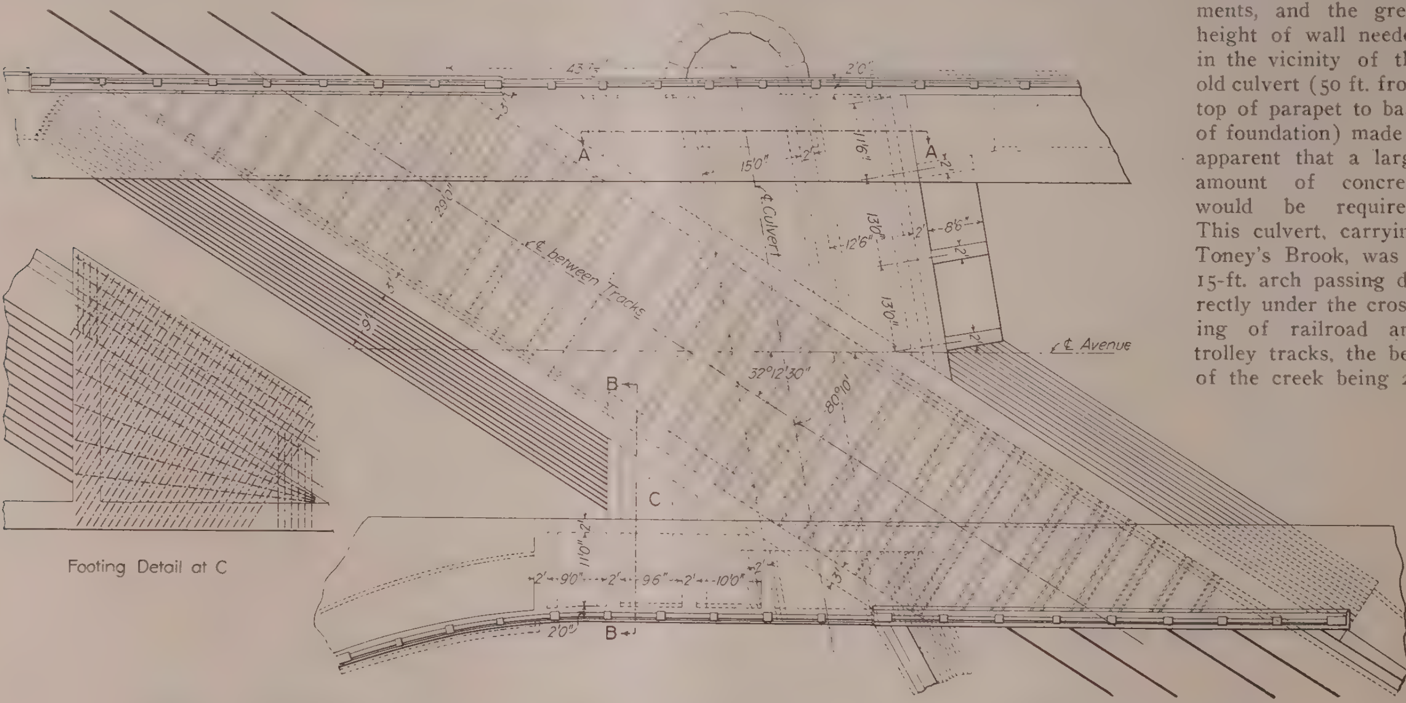
Renewing the Forth Bridge Floor

Since the famous Forth Bridge was put in service in March, 1890, the number of trains crossing it in one year has increased about 40 per cent and their tonnage has increased about 60 per cent. The maximum locomotive-axle load has increased from 16 to 20 tons. In consequence the floor is to be replaced with a new one designed for heavier traffic and higher speeds, according to "Engineering." The rails were laid on longitudinal oak timbers resting in plate and angle troughs, with a buckle plate floor between them. The new floor will be of a similar type, made of 17-in. channels instead of plates and angles, and the buckle plates will have their concave faces up instead of down as in the previous structure. The new floor, 7854 ft. long, will weigh about 2500 tons and will increase the load on the trusses only 750 tons. As no interference with traffic will be permitted on weekdays, and as only one track will be closed on Sundays, it is expected that the renewal will take several years. The bridge is subjected to a quarterly engineering inspection and is reported to be fully adequate for increasing future traffic except in the matter of floor strength.

Unusual Abutment Design

Hollow Reinforced-Concrete Triangular Boxes at Three-Level Crossing of Creek, Railroad and Avenue at Montclair

The elimination of the railroad grade crossing at Bloomfield Avenue, Montclair, N. J., involved problems conceded to be the most difficult of any encountered in similar work on the Montclair branch of the Delaware, Lackawanna & Western Railroad. Since this avenue is a main thoroughfare 80 ft. wide, carrying two trolley tracks, an adequate crossing had to be maintained at all times. The sharp skew of the crossing, the width of the avenue, the necessity for the extensive use of retaining walls to hold the approach embankments, and the great height of wall needed in the vicinity of the old culvert (50 ft. from top of parapet to base of foundation) made it apparent that a large amount of concrete would be required. This culvert, carrying Toney's Brook, was a 15-ft. arch passing directly under the crossing of railroad and trolley tracks, the bed of the creek being 22 ft. or so below top of rail. It was deemed unsafe to rely upon either the arch or the made ground adjacent to it to support the new masonry or embankment.

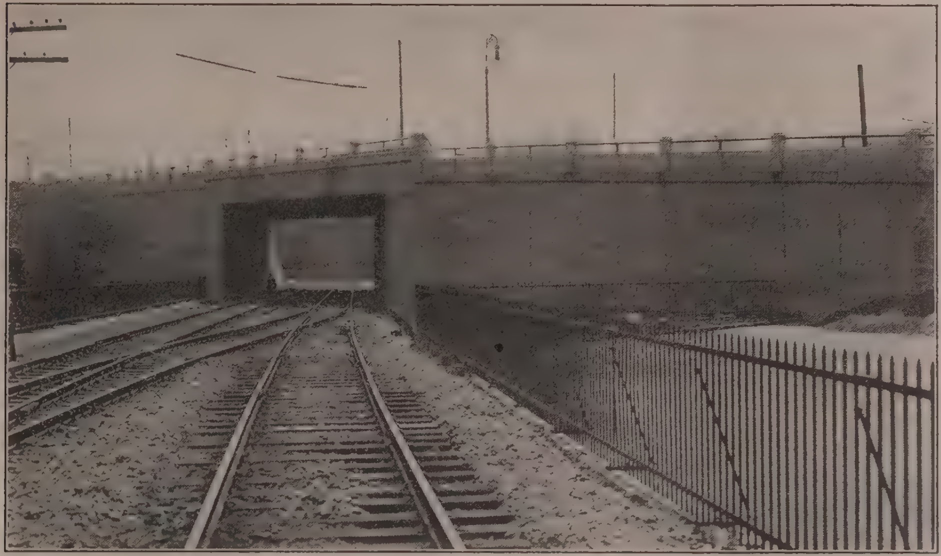


Plan of Bloomfield Avenue Crossing at Montclair, Showing Hollow Reinforced Triangular Boxes over Culvert

Triangular Boxes

Details are shown of the design adopted. The characteristic features are a reinforced triangular box over the culvert at each apex of abutment and retaining wall, with gravity sections for the parts of these structures sufficiently removed from the arch and the made ground. The abutment sides of the boxes are 3 ft. thick. In each abutment the wall is carried down to rock from the apex of abutment and retaining wall to the abutment of the old arch. For a depth of 6 ft. immediately over this arch the abutment wall was designed as a girder to support the load above. This girder was carried across to the beginning of the gravity section of the abutment, with an intermediate support on the other side wall of the old masonry arch. The parts of the retaining wall forming the box are 2 ft. thick, the foundations being carried down to various depths—to a maximum of about 28 ft. below top of rail.

The third side of the larger or upstream triangle is formed by a 2-ft. reinforced wall, buttressed, on a footing 13 ft. 9 in. wide, designed to spread the load over the made ground and exert a maximum pressure of 2 tons per square foot. To brace the entire structure and help carry the bridge floor, 2-ft.



View of Finished Bloomfield Avenue Bridge, Looking South

walls are carried up the full height on top of the culvert, the culvert itself being extended to the required length by walls 2 ft. 6 in. thick. The triangle is still further braced nearer the apex, as shown, by three 2 x 4-ft. reinforced struts, the top one of the three being incorporated in the bridge floor. Section A-A shows the depth to which part of the new work had to be carried.

Downstream Abutment

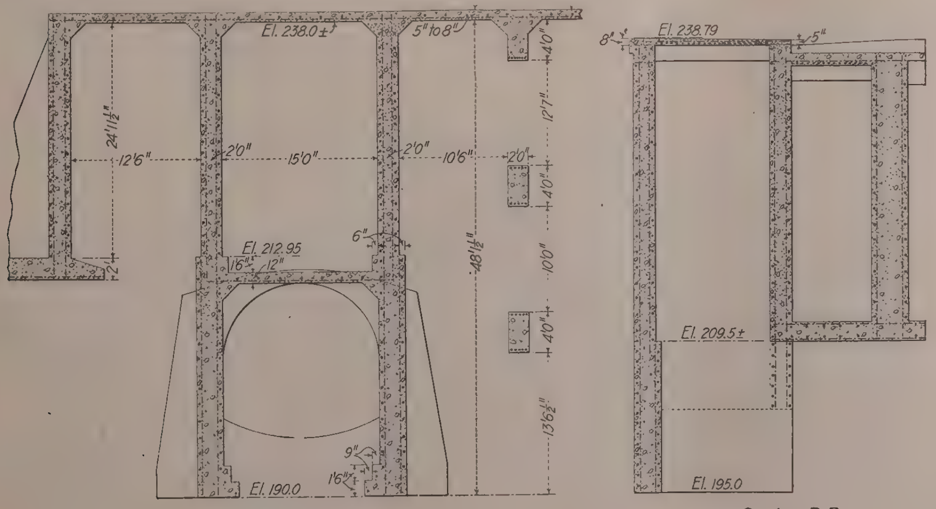
On the downstream side, where the culvert is nearer the intersection of the two walls, the box is smaller, but the foundation conditions are worse, solid ground being at a lower elevation. Here the abutment and retaining-wall sections are the same as for the other apex, but a different system of interior bracing was used, as shown, a 2-ft. wall parallel to the avenue being introduced under the curb line. The smaller triangle between this interior wall and the abutment is carried on a spread footing reinforced both ways and figured as exerting a uniform pressure on the soil underneath. This spread footing was introduced to reduce the soil pressure to 1½ tons per square foot. (This is made ground, but is well packed by heavy vehicular traffic.) The culvert was extended as at the other end and a wing wall was built to retain the fill for the second track.

The bridge is of reinforced concrete. The span of the fascia girders is 54 ft. 4⅞ in., and that of the beams at right angles to the abutments is 29 ft. The roadway floor is designed to carry a 50-ton electric car and a 15-ton roller. The beams carrying roadway for their entire length are differentiated from those partly under sidewalk, fewer bars being used in the latter. With the shorter beams spanning from the fascia girders to the abutment there are ten sizes of floorbeams.

Ornamental Work

Stepped backs were used for the abutments and battered ones for the retaining walls, which are surmounted with an ornamental balustrade—concrete posts and an iron-pipe railing. On one side of the avenue the retaining walls run the full length of the 5 per cent approaches, to avoid encroachment on dwelling-house property and a coal yard. On the other side is a park, and natural slopes were allowable most of the way. During the construction work a temporary crossing was maintained on this side, the trolley road being detoured to a new grade crossing and carried over Toney's Brook on a temporary pile trestle.

Reiter, Curtis & Hill, of Philadelphia, had the general contract for the work, which was carried out under the direction of Messrs. G. J. Ray, chief engineer, and G. T. Hand, division engineer. Mr. A. B. Cohen, concrete engineer, had charge of the concrete design and Mr. W. H. Speirs was resident engineer on the work.



Section A-A

Section B-B

Cross-Section of Hollow Reinforced and Braced Portions of Abutments

Cost of Concrete Base for Pavements in Los Angeles

By C. S. POPE
Assistant Engineer, Office of City Engineer

Different methods of laying the concrete base for pavements and their individual merits have often been discussed. The results obtained by the system used in Los Angeles offer to some extent a comparison of the efficiency of methods and labor. Mexican labor was used on the work, with the exception of the engineer and foreman, and the result indicates that, in spite of his reputation to the contrary, the Mexican is an efficient laborer under proper conditions.

The work consisted of laying a 5-in. concrete base for asphalt paving on Los Angeles Street from Eighth to Twenty-third Street. The concrete mixture specified was of Portland cement in 1:3:6 proportions. The roadway is 56 ft. wide between curbs and the base includes the strip 1½ ft. wide on each side, 4 in. thick, for granite block gutters. The base was laid in two strips, each approximately 28 ft. wide.

After having been brought to exact subgrade the surface of the street was dampened and thoroughly rolled wtih a 12-ton steam roller to as hard a surface as the soil permitted. The street was then planked for a distance of 500 to 600 ft. and sand and rock deposited on the planks in two rows. The concrete mixer used was of the Ransome self-propelling type and was fed by means of wheelbarrows dumped end-on into the mixer from a split runway. Cement was handled in a measuring bucket with a capacity equal to 27 per cent of the maximum capacity of the sand wheelbarrow. When the cement bucket was properly loaded and dumped no shortage of cement was possible due to the heaping-up of sand wheelbarrows or the fluffing of cement. The mixed concrete was dumped on planks and was handled and placed with scoop shovels.

The organization and daily expense of the gang was as follows:

1	Foreman		$5.00
1	Engineer		3.00
1	Cement supply man		3.00
1	Cement supply man's helper		2.25
1	Cement helper		2.00
1	Mixer and dump man		3.00
6	Wheelbarrow men	at $3.00	18.00
3	Shovelers	at 2.25	6.75
10	Carriers	at 2.00	20.00
3	Spreaders	at 2.00	6.00
1	Tamper	at 2.25	2.25
1	Clean-up man	at 2.75	2.75
1	Strip setter	at 2.50	2.50
1	Plank mover	at 2.75	2.75
2	Men and team		7.25
1	Sorter	at 2.00	2.00
1	Receiving clerk	at 2.75	2.75
1	Watchman	at 2.25	2.25
	Total		$93.50

From March 17 to 22 this gang averaged 1440 sq. yd. of base per nine-hour day at a cost for laying of slightly less than 6½ cents per square yard. On March 25, for a ten-and-a-half-hour day, exactly 2000 sq. yd. were laid at a labor cost of $105, giving a cost per square yard for laying of 5¼ cents.

The material costs (delivered in the following table, while not exact do not vary materially from the contractor's figures:

Cement	1121 sacks	at $0.50	$560.50
Sand	124 cu. yd.	at 0.65	80.60
Gravel	124 cu. yd.	at 1.55	192.20
Rock	124 cu. yd.	at 1.80	223.20
Labor laying 2000 sq. yd.			105.00
Mixer charged at $5			5.00
Total cost			$1,166.50
Cost per square yard			$0.582
Cost per square foot			.065

The daily average cost for six days was as follows:

	Per sq. yd.
Cement	$0.280
Sand	.040
Gravel	.096
Rock	.111
Labor	.065
Mixer	.003
Total cost	$0.595

The cost of placing a cubic yard of concrete during the six-day period averaged $93.50 ÷ 200 = $0.467, or 5.4 cu. yd. placed per man. The total cost was $4.28 per cubic yard.

Traffic and Wear of English Highways

Cost of Maintenance, Effect of Motor Vehicles and Methods of Surface Treatment

The need of a central controlling body to supersede the present complex highway organization in England was dwelt upon in an address by Mr. Charles Hamlet Cooper before the Society of Engineers, Westminster, London. Mr. Cooper deals further with the changes in character of traffic reflected by road censuses and with British highway practice, especially as observed in his own experience. An abstract of his remarks is given in the following:

The highway authorities of England and Wales include 51 county councils, 75 county boroughs, 249 boroughs, 821 urban district councils, 657 rural district councils, the London county council, the city corporation, and 28 metropolitan boroughs, a total of 1883, each independent within its own district, controlled only by Government departments and county councils in carrying out work for which grants are made. Although three Government departments—the Local Government Board, the Board of Trade, and the Road Board, exercise certain functions in respect of highway authorities, none of these departments controls such authorities as regards work paid for out of local funds.

The necessity for a central controlling body is pressing at the present time, since traffic has undergone such a radical change. Motor traffic, with increased speeds and loads, requires wider and straighter roads that intersect, so as to allow approaching vehicles to view each other at the earliest possible moment, while the road crust must be capable of carrying the traffic to which it is now subjected. It is impossible to effect these improvements in roads passing through the districts of various highway authorities, most of whom may be quite willing to accept a general scheme for improvement, unless the consent of all authorities can be secured.

MAINTENANCE APPROPRIATIONS

An instance of the need of a reorganization of highway authority is found in the disproportionate appropriations for maintenance. At the recent International Road Congress the mileage of surfaced roads in England was given as follows: Permanent pavements, 4000; bituminous-bound roads, 4650; water-bound macadam, tar-sprayed, 16,000; water-bound macadam, 123,000; unmetalled, 2857; total, 150,507.

These roads are maintained at an expenditure of $75,263,675, or $500 per mile. To meet this expenditure the taxes are: On motor vehicles, $1,742,200; on petrol, $2,657,100; other Imperial taxes, $7,825,350; local taxation, $63,039,025; total, $75,263,675.

Of the total expenditure on highways 83¾ per cent has to be found out of local rates.

The motor vehicles using the highways are as follows: Pleasure motors, 80,468; commercial motors, 14,000; motor omnibuses, 4000; public automobiles, 27,260; motor cycles, 63,680; total 189,408.

Rural districts naturally are unwilling to pay 83¾ per cent of the upkeep of their highways, the wear of which is mainly due to traffic foreign to their district.

TRAFFIC

In order to show the changes that have taken place in the traffic carried by highways Mr. Cooper gives a synopsis of the traffic returns at Putney Bridge on a Sunday in June or July since 1905, which show the change in pleasure traction, while the returns on weekdays in Fleet Street show how ordinary traffic has changed. These returns are confined to the day traffic, but they are sufficient to show how rapid has been the change from animal to mechanical propulsion, while the total traffic has increased enormously.

CHANGES IN RELATIVE WEIGHTS OF HUMAN, ANIMAL AND MECHANICAL TRAFFIC, AS DISCLOSED BY SINGLE-DAY TRAFFIC COUNTS IN LONDON

Putney Bridge (Sunday)	1913	1912	1911	1910	1909	1908	1907
Human	35.82	45.00	50.14	53.15	54.56	52.34	56.88
Mech.	62.50	53.02	46.52	41.53	31.53	27.55	22.81
Animal	1.68	1.98	3.34	5.32	13.91	20.11	20.31
Fleet St. (weekday, 12 hours)							
Human	17.50	18.28	15.66	14.81	13.73	6.97	14.99
Mech.	45.35	42.54	39.47	37.43	21.91	21.33	11.29
Animal	37.15	39.18	44.87	47.76	64.36	71.70	73.72

Costs of maintenance per mile given in the Local Government's report for 1910 and 1911 show that so far the introduction of motor traffic has not materially increased maintenance expense, while in the well-paved streets of London the cost has decreased 29 per cent.

REASONS FOR ROAD FAILURES

The excessive damage caused by motor omnibuses and vehicles taking heavy loads at high speeds is due to the impact with which the wheels carrying such loads strike depressions in the road surface and, as it were, knock the bottom out of such depressions, thereby forming hollows. The impact increases with the depth of the hollows, and as water settles in these hollows the road crust goes rapidly to pieces. The impact causing these hollows might to a great measure be avoided if such traffic were carried on three axles instead of two, as at present. A good example of what might be expected by the adoption of this principle may be seen from the roads rolled by a three-axle roller, which produces a much more even surface than the ordinary two-axle roller.

When stones of various sizes are used the large stones invariably work to the surface, and will destroy the effect of any surface dressing so far as it is intended to render the surface impervious. In addition to the tendency of the large stones to work to the surface such large stones predominate in certain parts of the layer, and there is no means of insuring a uniform mixture of the various sized materials.

In the various books and papers that deal with road crusts Mr. Cooper has failed to find any reference to the force that appears to him most destructive. Such works deal with the road crust as the conveyor to the ground beneath of weights that come on to its surface, and the depression caused thereby, but no mention is made of the force of upheaval that acts contiguously to the area of depression. In fact, we have been considering road crusts in a somewhat similar manner to the voussoir of an arch, which conveys the weight carried by the bridge to the abutments and thence to the foundations. If such an arch had to withstand forces from beneath, it would be necessary to introduce tension rods on the extrados to counteract such forces. The force causing the upheaval which takes place in the case of a road crust acts in an exactly similar manner to that of a force introduced beneath an arch, and should be resisted by surfacing material having as great a tensile strength as it is possible to obtain with economy, such as would be afforded by a tough bituminous coating. No better method could be devised to destroy such tensile strength than by introducing large stones into such a coating; and as it is essential that the coating should be as homogeneous as possible, the introduction of various sizes of stone is most deleterious. In such a surface coating there are several forces set up by the wave-like action that takes place, and it is essential, in order to prevent destruction from these combined forces, that the surface coating should be as homogeneous as possible, and at the same time tough and resilient. Mr. Cooper feels certain that if these conditions had been complied with, the failures that have resulted throughout the country from the use of asphalt surfacings would not have occurred.

On many roads a thin layer, 1 to 1½ in., of tarred granite, at a slightly greater cost than that of repairing the water-bound surface, has rendered the road impervious, and, so far as can be seen, immune from the effect of weather, so that it is able to carry much greater traffic, and in many cases a small amount of motorbus traffic. It is recommended that this material should be laid on the surface of an ordinary macadam road, which should not be disturbed by scoring.

The surface dressing generally used by Mr. Cooper is gas tar containing not more than 5 per cent of water to which pitch in the proportion of a pound to 3¾ imp. gal. of tar is added, heated to 160 to 180 deg. Fahr., discharged direct from the boiler on a well-swept road surface and worked in with rubber squeegees, and then covered with ⅜-in. Guernsey granite chippings rolled in.

The cost per square yard is 2.96 cents, made up as follows:

	Cents
Labor in sweeping clean and spreading	0.57
Tar and pitch	1.20
Granite chippings	0.79
Rolling	0.08
Carting and hire	0.32
	2.96

The following table taken from the reports of the London traffic branch of the Board of Trade shows that the number of passengers carried by omnibuses has increased 344 per cent between 1886 and 1911. During the period under consideration the population of Greater London increased only 40 per cent.

NUMBER OF PASSENGERS CARRIED BY OMNIBUSES

Year	Passengers	Estimated population of Greater London	Journeys per head in buses
1886	90,708,966	5,182,130	17.5
1891	158,926,250	5,633,806	28.2
1901	269,933,759	6,581,372	41
1909	311,000,000	7,112,145	43.9
1910	377,207,555	7,181,415	52.5
1911	400,628,487	7,251,358	55.2

Another comparison is afforded by the fact that the number of persons carried by horse omnibuses in 1903 was 287,386,471, while those carried by motorbuses in the year ended March, 1913, totaled 539,250,000.

Model Mining Town of Kincaid

Plan to Enable Workers to Own Their Own Homes Is Inaugurated to Develop High Grade of Men

GARDEN-CITY ideas are being worked out for a mining town of 5000 population in Christian County, Illinois, 200 miles south of Chicago and 100 miles northeast of St. Louis. Kincaid is being built to house in a sanitary, efficient and economical manner the laborers employed in a mine and a "pit-mouth" power station owned by the Middle West Utility Company, a corporation which controls about fifty electric-light, waterworks and public-utility plants within a radius of 50 miles. The existing steam-turbine-driven plant has a capacity of 3500 kw.

The distinct and interesting feature of the enterprise is the attempt to make practical, town-planning ideas for an average population in the coal-mining district. The advantage of small garden plots, small farms which are grouped and the interspersion of numerous parks are central thoughts around which other features have been built up.

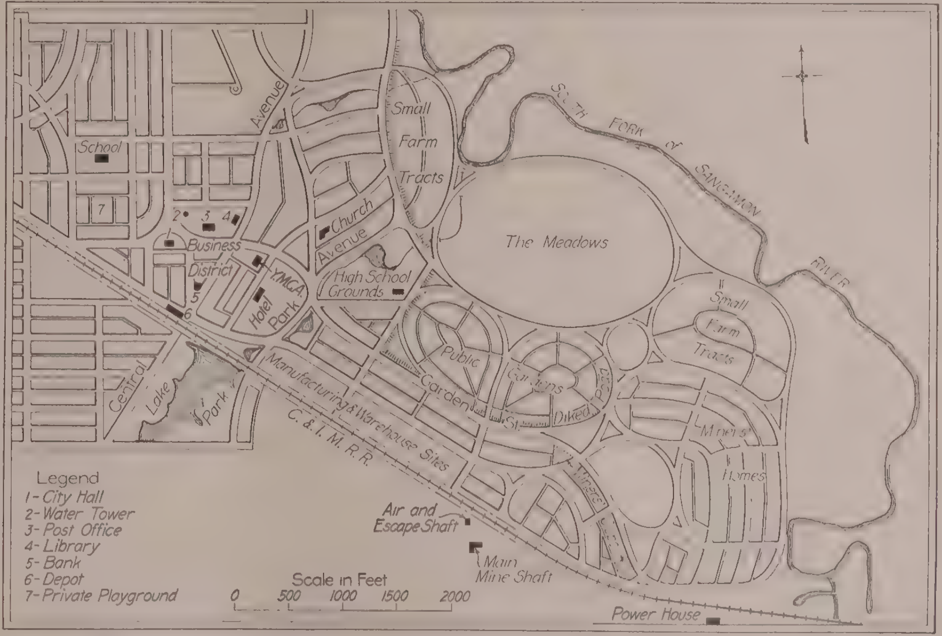
Any reputable miner with a small deposit may purchase a lot and arrange with the town building company to construct his home. With the lot goes the privilege of a garden plot and the use of the common meadow to graze his cow. If he is more ambitious, he may select a small farm. It is the idea that a home-owning miner will prove a better and more satisfied laborer than one who simply rents. Stability of the community, prevention of strikes and contentment of the men are hoped for as an outcome of the venture.

The promoters will retain control of a bank and the miners' clubs, which are to be modeled after the German beer gardens.

Layout

Only one section, that of the business district, was fixed in location. This is placed on higher ground than the remainder of the gently rolling prairie, about ½ mile from the mine and the power house. The south fork of the Sangamon River, which runs along one side of the property, is a stream with a very small summer flow, but in floods, which occur at comparatively long intervals, it occupies a wide flood plane extending to the diked road shown on the map. It is the idea to prevent damage by utilizing the flooded area only for farms, parks and the common meadow, restricting building operations to the higher land.

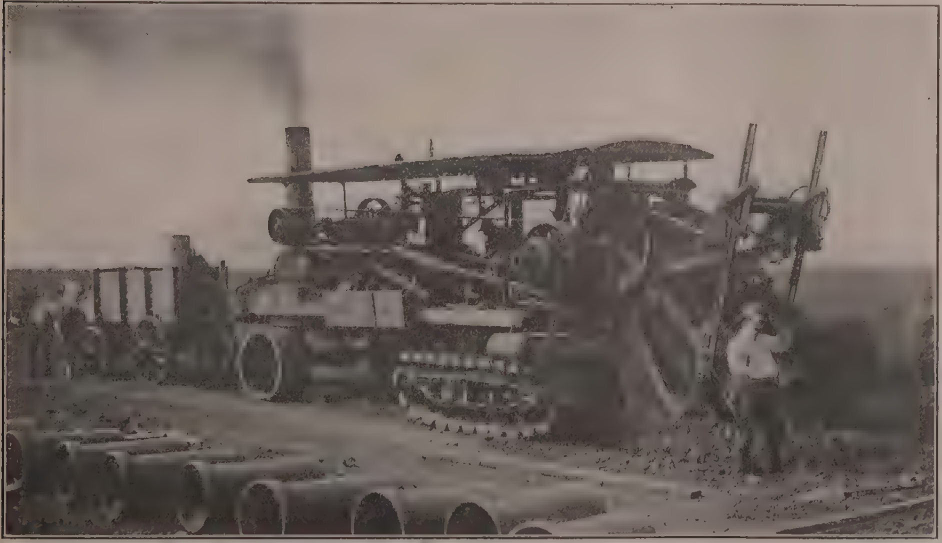
Following the foreign garden-city practice, few streets are straight, or are laid out on "sweep" curves, particularly in the residential districts. The plots apportioned to business and civic buildings, to manufacturing, to various classes of residences and to small farms have all been grouped, and in disposing of the lots the selling contracts carry building restrictions which will not permit factories to invade residence districts or allow the erection of dwellings inferior to approved designs.



General Map of Southern Illinois Model Mining Town of Kincaid

More than a dozen plans of modern five-room houses for the miners, to cost about $1,000 each, will be furnished to prospective buyers, but the purchaser may build on his own plans if he can secure their approval by the town architect. In the section devoted to the homes of miners the lots are 30 ft. wide. Larger lots up to small farms are available, but there is a group of 50-ft. lots, one of irregular plots of an acre or so, and still another area set aside for small farms.

All public or semi-public buildings are to be surrounded by parks, while numerous open spaces, private playgrounds and small parks will afford plenty of open space.



Caterpillar Trenching Machine Used on Kincaid Sewer Work

Development and Present Status

Eight years ago Mr. F. S. Peabody, of the Peabody Coal Company, started to purchase land on which to build the town. A railroad spur from Auburn to Pawnee, a few miles west of Kincaid, built by farmers, was purchased and extended to Taylorville, 6 miles east of Kincaid. It is 25 miles long and connects with the Baltimore & Ohio, the Wabash, the Illinois Central and the Chicago & Alton railroads. Finally, 1200 acres were secured, the farmers being induced to sell mainly because of the advantages to be gained by the rail connection, which eliminated a 20-mile haul. Nothing was done on the site until this year, and no building will be permitted—in fact, no land will be sold—until the public utilities are well along toward completion.

At present 7 miles of streets have been graded; 4½ miles of a total of 7 miles of sewers have been laid; a contract for 200,000 sq. ft. of sidewalk for the residential district was let in October; a water supply is being sought, and plans for a sewage-disposal system are being drawn.

Streets and Sidewalks

In grading streets the diked road was raised in places from 4 to 6 ft. to preclude any overflowing from the river. No pavements will be laid until the fills and trenches have had a chance to settle one year. They will be brick laid on a 6-in. concrete base. In the residence districts the streets are 66 ft. wide, with 21-ft. parkways on each side, while in the business section the streets are 80 ft. wide, with a 40-ft. width paved.

Sidewalks are 5 ft. wide in the residence district and are laid 1 ft. from the property line. The present contract, let to John Brogan, calls for laying sidewalks for about 4 miles on both sides of the street. The walks will rest on 4 in. of cinders obtained from East St. Louis, and will be made of 1 : 2 : 4 concrete, 4¼ in. thick, with a ¾-in. top of 1 : 1½ mixture. Walks in the business district are left for the buyer to build, as he may desire to use the vault space under the walks.

SEWERS

Sewers varying from 8 to 15 in. in diameter are being laid this season in trenches from 5 to 19 ft. deep and 24 in. wide, dug by an Austin No. 1 caterpillar trenching machine. The material is a clay which requires little bracing except for the deeper work. Here it breaks off in large masses about 8 ft. deep and 4 ft. back from the trench. To hold the banks vertical 2 x 10-in. planks were spaced 2 or 3 ft. apart and braced by trench jacks at 4-ft. intervals. For at least 1 ft. over the pipe the backfill is hand-tamped.

Some difficulty was encountered by the contractor when digging the deepest trench from the front wheels sloughing from side to side, but this was overcome by riveting 4-in. angles to the rim of the front wheels. An average day's work of ten hours was 500 ft., but a maximum of 750 ft. was attained. The pipe-laying gang followed the excavator closely, usually not more than 75 ft. away.

Manholes of concrete were constructed over the pipes and when completed the pipes were broken out. This procedure permitted the ground water to be carried through the manhole during erection and the inverts to be formed in the dry. Little water was encountered except in deep cuts.

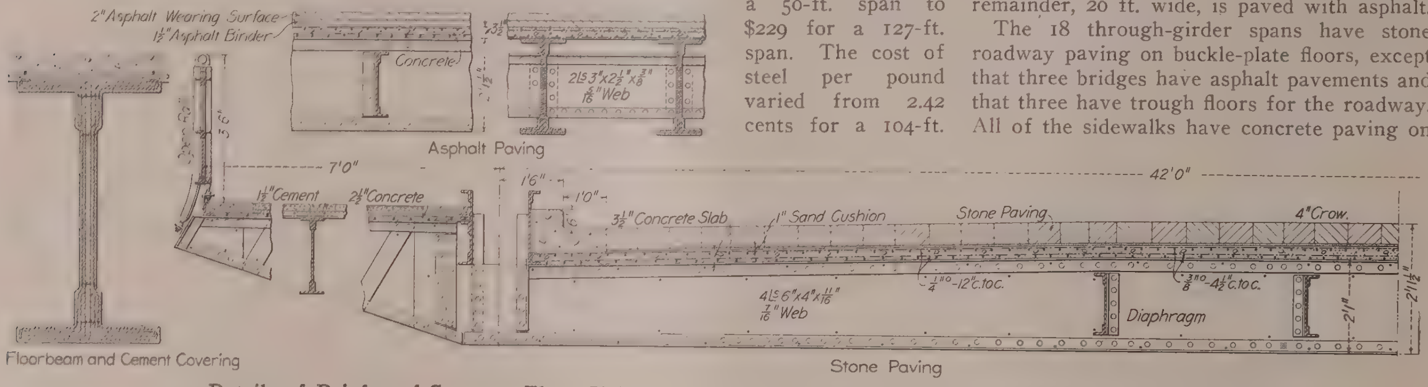
Alvord & Burdick are the consulting engineers for the town-site project, to which Messrs. Peabody and Insull, of the Middle West Utility Company, have given much personal attention. Sargent & Lundy are the engineers for the power plant. Mr. O. C. Simonds is the landscape architect caring for the park system and Mr. George Maher is the architect designing the public buildings and planning the houses. Mr. A. T. Luce is the resident engineer in charge of the construction work.

Weight and Cost of Bridges

Comparison of Different Types of Short-Span, Overhead, Grade-Crossing Bridges in Buffalo Having Asphalt, Wood and Stone Flooring

THE overhead highway bridges constructed several years ago by the grade-crossing commissioners of the city of Buffalo to eliminate grade crossings over the steam railroads in that city include eighty-three spans from 25 to 194 ft. long over all, with asphalt, wood and stone roadway paving on trough, buckle-plate, and reinforced-concrete floors and with plank and concrete sidewalk paving on plank, concrete and buckle-plate floors.

These bridges are of through-truss, pony-truss, through-plate-girder, and deck-plate-girder construction. With two exceptions the width over all is either 50 or 56 ft., and the cost per linear foot varied from about $71 for a 50-ft. span to $229 for a 127-ft. span. The cost of steel per pound varied from 2.42 cents for a 104-ft. span to 4.07 cents for a 127-ft. span. In all cases the costs given are for the complete superstructures alone, inclusive of painting, paving, etc., and exclusive of substructures. They are based on the actual contract prices, exclusive of engineering or any other expenses.



Asphalt Paving

Floorbeam and Cement Covering

Stone Paving

Details of Reinforced-Concrete Floor Slabs with Stone Roadway Paving on Louisiana Street Bridge

LOADING

The bridges were built in accordance with the 1901 specifications issued by the grade-crossing commission, and provided for a live-load on trusses and girders of 100 lb. per square foot over the roadway and sidewalks. All floorbeams were proportioned for a live load consisting of a 15-ton steam road roller with 6 long tons on the forward axle and 9 long tons on the rear axle, 11 ft. away, with rollers 20 in. wide, spaced 2½ ft. apart on centers on the forward axle and 6 ft. apart on centers on the rear axle. In addition to the roller load the clear portions of the roadways were assumed to be loaded with 100 lb. per square foot. All lateral systems were proportioned to sustain a wind pressure of 50 lb. per square foot of exposed surface.

All spans are 56 ft. wide over all, with trusses or girders 42 ft. apart on centers, except for 52-ft., 42.5-ft. and 67.8-ft. bridges, which are 50 ft. wide with 36-ft. centering, and all through spans have two 7-ft. sidewalks, except that those of one 47.7-ft. span are 10 ft. wide.

TYPES OF ROADWAY

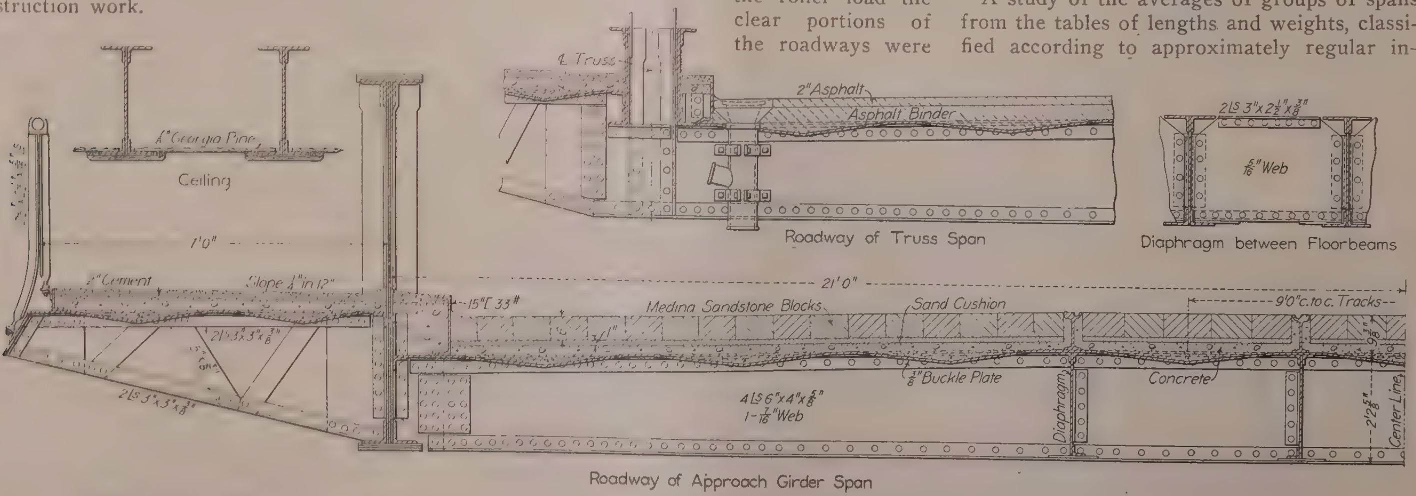
All through truss roadways are paved with asphalt, except that on one 150-ft. span a strip 19 ft. wide is paved with wood and the remainder, 20 ft. wide, is paved with asphalt. The 18 through-girder spans have stone roadway paving on buckle-plate floors, except that three bridges have asphalt pavements and that three have trough floors for the roadway. All of the sidewalks have concrete paving on buckle-plate floors, except on three trough floor spans, which have plank sidewalks.

The seven pony-truss spans have reinforced-concrete roadway floors and concrete sidewalk pavements. The roadway floors have stone pavements, except for one bridge, which has asphalt pavement.

Of the twenty deck plate girder spans eleven are 56 ft. wide over all and have 8½-ft. sidewalks; 52-ft. and 68-ft. spans are 50 ft. wide; a 29-ft. span has a 10-ft. sidewalk; the 50 and 60-ft. spans have 8-ft. sidewalks; the 66-ft., 76-ft. and 78-ft. spans have 7-ft. sidewalks; the 25-ft. and 57-ft. spans have no sidewalks. The roadways are all paved with stone, except for the 54.5-ft., 66-ft., 76-ft. and 78-ft. spans, which are paved with asphalt.

CONDENSED DATA

A study of the averages of groups of spans from the tables of lengths and weights, classified according to approximately regular in-

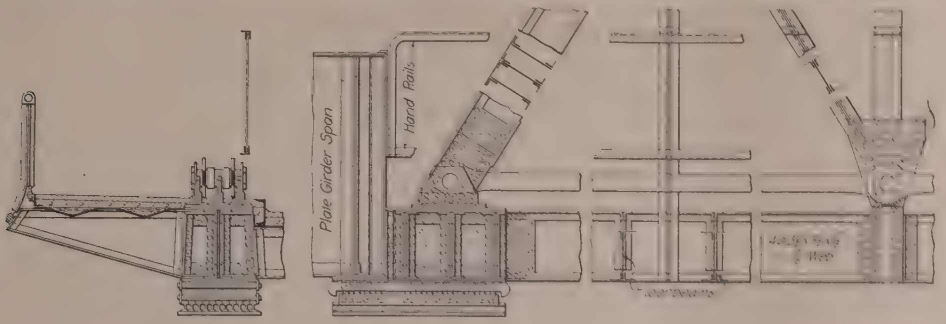


Roadway of Truss Span

Diaphragm between Floorbeams

Roadway of Approach Girder Span

Buckle-Plate Floor with Asphalt Pavement on Approach Span and Stone Pavement on Truss Span, Seneca Street Bridge



Floorbeam, Longitudinal Girder, and Vertical-Post Connections, Seneca Street Bridge

crements of lengths and type of floor construction, shows that in eight through-truss spans, varying from 100 to 116 ft. in length, with total widths of 56 ft. and having buckle-plate floors, the average span length was about 109 ft.; weight, 490,000 lb.; weight per linear foot, 4500 lb.; and cost, 3.0675 cents per pound of steelwork.

For eleven through-girder spans from about 52 to 81½ ft. long and 56 ft. wide, with buckle-plate floors, the average length was 65.8 ft.; weight, 272,000 lb.; weight per linear foot, 4140 lb.; and cost per pound, 2.71 cents. For four pony-truss spans, from about 52 to 60 ft. in length and 56 ft. in width, with reinforced-concrete floors, the average length was 54.86 ft.; weight, 130,600 lb.; weight per linear foot, 2380 lb.; and cost of steel, 4.09 cents. For three pony-truss spans of about 74 to 81 ft. length the average length was 77.6 ft.; weight, 256,700 lb.; weight per linear foot, 3310 lb.; and cost, 4.08 cents per pound, thus showing an increase of nearly 97 per cent in the weight, corresponding to an increase of about 41 per cent in the length of span, other conditions being equal. For six deck-plate-girder spans, from 50 to 60 ft. long and 56 ft. wide, with buckle-plate floors, the average length was 53.6 ft.; weight, 120,100 lb., weight per linear foot, 2240 lb., and cost, 3.267 cents per pound.

The pony-truss spans weigh about 140 lb. per linear foot more than the deck-plate-girder spans with reinforced-concrete floor slabs of approximately the same length, giving an increase of about 6 per cent in the weight of the steel and an increase of about 25 per cent in the pound price, the latter, however, being perhaps due to the construction of the bridges at different times. The 52-ft. through-plate-girder span with buckle-plate floor weighs about 34 per cent more than the average 53.6 ft. deck-plate-girder span with buckle-plate floor and cost about 26 per cent more per pound. The 55-ft. through-plate-girder span with buckle-plate floor is about 50 per cent heavier than the 54.8-ft. average pony-truss span with reinforced-concrete floor and cost 7 per cent less per pound. The 77.6-ft. through-girder span with buckle-plate floor weighs about 23 per cent, weighs more than the average pony-truss span of the same length, and the steel cost about 22 per cent less per pound.

Typical Features of Design

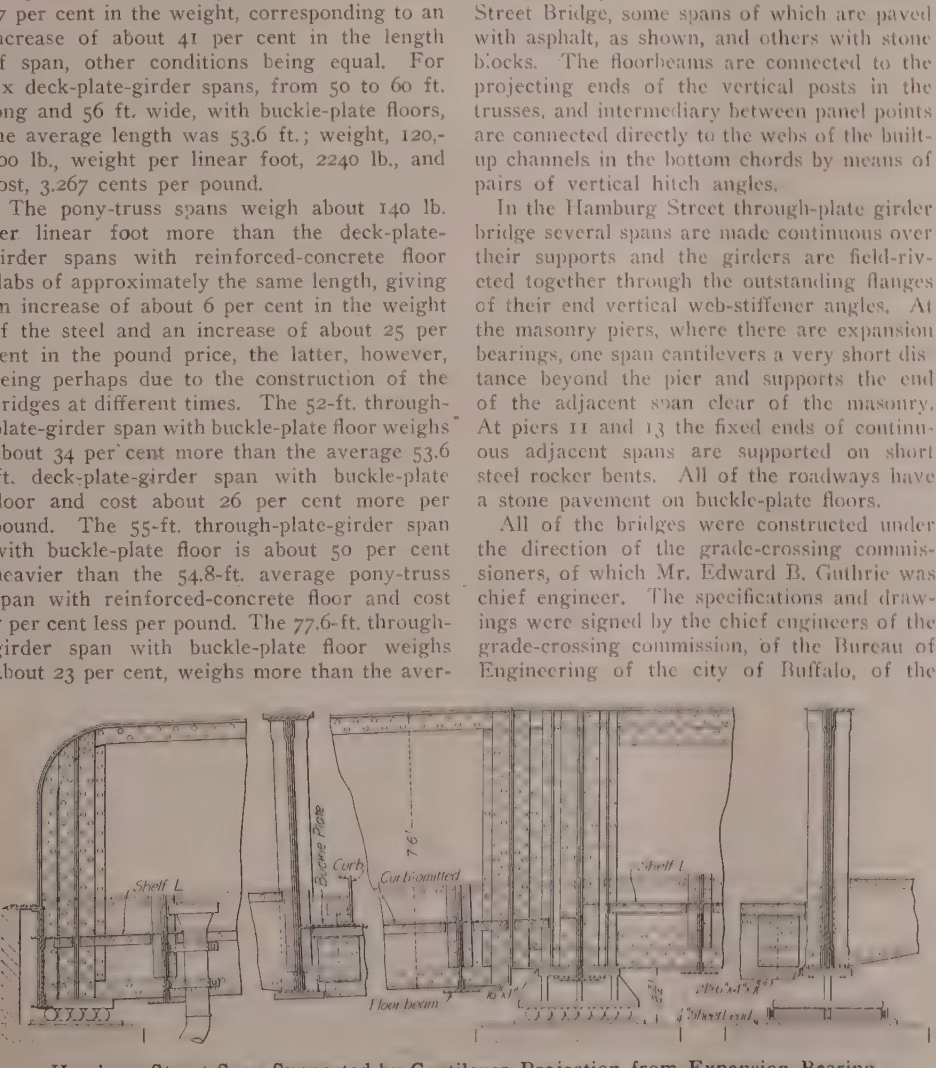
The construction of the buckle-plate floors is illustrated by the typical detail of the Seneca Street Bridge, where stone paving was used on the approach plate-girder spans and asphalt pavement on the truss spans. The floorbeams are web-connected to longitudinal plate girders in the planes of the trusses and field-riveted to extensions of the vertical posts below the bottom-chord pins. At the ends of the spans the longitudinal girders are connected to riveted pedestals inserted between the end shoes of the trusses and the fixed or expansion bearings on the piers. In these spans the floorbeams are protected from locomotive smoke and gases by wooden ceilings attached to their bottom flanges.

The reinforced-concrete roadway floors are illustrated by the details of the Louisiana Street Bridge, some spans of which are paved with asphalt, as shown, and others with stone blocks. The floorbeams are connected to the projecting ends of the vertical posts in the trusses, and intermediary between panel points are connected directly to the webs of the built-up channels in the bottom chords by means of pairs of vertical hitch angles.

In the Hamburg Street through-plate girder bridge several spans are made continuous over their supports and the girders are field-riveted together through the outstanding flanges of their end vertical web-stiffener angles. At the masonry piers, where there are expansion bearings, one span cantilevers a very short distance beyond the pier and supports the end of the adjacent span clear of the masonry. At piers 11 and 13 the fixed ends of continuous adjacent spans are supported on short steel rocker bents. All of the roadways have a stone pavement on buckle-plate floors.

All of the bridges were constructed under the direction of the grade-crossing commissioners, of which Mr. Edward B. Guthrie was chief engineer. The specifications and drawings were signed by the chief engineers of the grade-crossing commission, of the Bureau of Engineering of the city of Buffalo, of the Lake Shore & Michigan Southern, the New York Central & Hudson River, the West Shore, and the Erie Railroad Companies, and by the chairman of the grade-crossing commission.

The bridge construction was also participated in by the Western New York & Pennsylvania, the New York, Chicago & St. Louis, and the Buffalo Creek railroads.



Hamburg Street Span Supported by Cantilever Projection from Expansion Bearing

Highway Construction in the Philippines

Experiences with Native Labor and Use of Coral as Road-Building Material

There were 245 miles of first-class roads in the Philippine Islands in 1908; in 1912 there were 1105 miles. Previous to the organization of the Bureau of Public Works in 1905 all improved roads, except those maintained for military purposes, had deteriorated until they were often impassable. When the work of rehabilitating the Insular roads was put in charge of the Bureau of Public Works a comprehensive road system was outlined. The islands were divided geographically into four divisions, each division comprising seven to nine provinces, and placed in charge of division engineers, who receive instructions from the chief division engineer at Manila. Under each division engineer are district engineers in charge of the work in each province.

Interprovincial Routes

Standard designs of road construction were prepared and connecting interprovincial routes of communication established. The present work of the bureau consists primarily of constructing improved or so-called first-class roads according to a comprehensive plan, the maintenance of unimproved or second class roads until they can be reached by first-class construction, and the laying out of cart trails and bridle paths. The money for road work is provided from provincial funds, a percentage of the internal revenue, land tax and various appropriations of the Philippine commission and legislature.

The general system of construction employed by the Bureau of Public Works under different topographical conditions is described by Mr. D. E. Henry, acting division engineer, in the "Quarterly Bulletin" of the Bureau of Public Works. The country may be classified as to character of soil and topography as rice paddy, coastal, bench or rolling, and hilly or mountainous. The following account of the various methods of construction employed in these different sections of the country is taken from Mr. Henry's report.

Grades

The grade line through rice paddies is raised slightly above the average tops of the paddy dikes. On bench lands the grade line follows the contour of the ground more closely, for usually the drainage is perfect. The grade on coastal roads is kept well above high tide and protected from the surf, which may do serious damage during storms. Sometimes along coastal routes an arm of the sea, or estuary formed by the mouth of a river, is crossed in order to shorten distance. This requires a causeway to be thrown up above high tide. These causeways are subject to the attack of crabs, which honeycomb the embankment, and at times they may be observed as thick as prairie dogs in their native cities. The establishing of grades in hilly or mountainous country presents the most difficult problem, owing to the unstable character of the formation, which has been disturbed by earthquake shocks, and the heavy grades that are necessary. The crown on heavy grades is increased considerably.

Various methods are practised in building the subgrade. Wheelbarrows are generally used to move earth from the borrow pit or ditch into the roadbed. One man loosens the material, another loads it into the wheelbarrow, another wheels it to the embankment, and still another levels off the earth. Four men will move not more than 3 cu. m. per day. Small baskets carried on the shoulder by one man or a "dagadaga" swung from a bamboo pole and carried by two men are used for transporting material. There is also employed a native bamboo sled, hauled by a carabao.

The wheelbarrow method referred to is improved where each laborer is given a wheelbarrow, mattock and shovel, and works independently of any other laborer. Each laborer will move from 1 to 1½ cu. m. of earth per day. In all probability the most effective and economical method is by contracting in short sections to the natives by the lineal meter. In this way a number of natives get together, select a "capataz" who understands the work, and contract from 100 to 500 lin. m. They are furnished all tools and accessories, and where blasting is required dynamite is furnished. Contracting by the cubic meter has been tried, but it has not given the best results as compared to contracting by the lineal meter. As a comparison, 1 cu. m. per day is a fair average for the laborer in the Philippines, while 10 cu. m. per day are the average in the United States on railroad work, where the distance from the borrow pit to the embankment is 50 ft. or less.

SURFACING MATERIALS

Several surfacing materials are used successfully. Stone and gravel are used in much the same way as in the United States. Sometimes the roads are constructed of a telford base of adobe stone 12 in. deep, with a top or wearing course of broken stone 1 to 2 in. deep. Adobe stone is found in many parts of the islands and is easily quarried and handled. Again, a telford of coral 8 to 12 in. deep is used, with a top course of finger coral. The coral used in the telford base is found in deposits along the seashore and can be quarried with a pick. The finger coral is found washed out by wave action along the coast line. This type of road costs little to construct, does not necessarily require compacting, as its cementing quality is high, presents a very smooth, white surface and justifies its use where traffic is not too heavy, as it forms a good base upon which to build a more durable surfacing when traffic warrants it.

Where the waters, rushing down the valleys, spread out on the low coastal plain the roads are usually located upon the higher contours. If this is prohibited by excessive cost, cogon grass, which is tough and fibrous and grows to a height of 10 ft. in nearly all localities, is cut and laid on the top of the sand road and in a short time becomes bedded into it. Sand-clay construction would be a better method, but is more expensive, and one application of the cogon grass lasts the entire season.

Gravel roads, using two courses of gravel and a filler of volcanic earth found usually about 2 ft. under the surface soil, are successfully made where there is a dearth of other materials. The filler or binder is placed in unusually large quantities, and especially over the last course, the surface being maintained with the same material. An instance of this class of construction is found in one of the northern provinces, where 13½ miles have been constructed with a 3-ton roller. This surfacing wears well under traffic and for all intents justifies this class of construction.

Electrolysis Clauses of Chicago Street-Car Ordinance

Division of City into Three Zones, with Permissible Differences of Potential of 10, 15 and 20 Volts Respectively

The ordinance providing for the unified operation of the surface railways of Chicago, passed by the city council Nov. 13, has been signed by the mayor. The first part of the ordinance deals with questions of operation and accounting, in which the engineer has no direct concern. The sections relating to the mitigation of electrolysis should interest him, however, and are therefore printed in full, as follows:

"Section 8. The companies shall continue to be bound by and to comply with the provisions of the ordinances of 1907 relating to electrolysis, and particularly with the provision from paragraph headed 'Bonding' in Exhibit B reading as follows: 'The rails shall be so bonded or joined and such return circuits and other necessary devices installed as to prevent damage from electrolysis as effectually as possible'; and toward that end the companies are hereby required and agree to comply with the following terms, provisions and conditions with reference to electrolysis:

THREE ZONES

"(a) For the purpose of preventing damage by electrolysis the city of Chicago shall be divided into three zones.

"(b) All uninsulated electrical return circuits shall be of such current-carrying capacity and so arranged that the sustained maximum difference of potential between any two points on any uninsulated portion of such circuit will not exceed the limit of 10 volts in the inner zone, 15 volts in the middle zone and 20 volts in the outer zone; provided, however, that such sustained maximum difference of potential between any two such points in the grounded portion of the negative return shall not exceed a limit to be, from time to time, prescribed by the Board of Supervising Engineers; and provided further, that the Board of Supervising Engineers shall have the power to increase the maximum drop in the outer zone to 25 volts at such points as may be deemed advisable by the board for the extension of track into outlying districts of the city where the underground utilities are not fully developed. The term 'sustained maximum difference of potential' is hereby defined as the highest average difference of potential for any thirty-minute period during normal conditions of operation. Wherever pipes or other underground metallic work are found to be electrically positive to the rails or to the railway return circuit, they may, upon the direction of the Board of Supervising Engineers, be connected by conductors so arranged as to prevent the flow of current from the pipes into the ground, and any damage caused by such connections shall be borne by the company or companies making such connection.

"(c) The Board of Supervising Engineers shall, as often as it deems necessary, make such tests to determine whether or not the companies are complying with the provisions of this ordinance, and, to enable said board to make such determination, the companies agree to install, from time to time, such electrical apparatus and necessary devices as the Board of Supervising Engineers may direct.

"(d) The companies shall, within three months from the date of the passage of this ordinance, file with the Board of Supervising Engineers and the city electrician a statement showing the plans that have been adopted for complying with the requirements of this ordinance, and at the expiration of each six months' period thereafter the companies shall file with the Board of Supervising Engineers and the city electrician a statement showing the progress made by the companies in complying with the requirements of this ordinance; and the companies shall within 1 year from and after the date of the passage of this ordinance have completed with at least two of its power supply stations, whereby the provisions of this ordinance shall have been complied with throughout the region supplied by said stations, and within the period of 2 years from and after the date of the passage of this ordinance its provisions shall be fully complied with by the companies throughout their entire railway systems by the expenditure by the companies of not less than $1,000,000, as directed by the Board of Supervising Engineers, if, in its judgment, this expenditure is necessary within this time. The companies shall further expend such additional amounts upon return circuits and other electrical apparatus over and above that necessary to comply with this ordinance as the Board of Supervising Engineers may, from time to time, prescribe, in order to prevent damage from electrolysis.

PENALTIES

"(e) In case any company fails to comply with the provisions of this section, such company shall be subject to a fine of not less than $50 or more than $200 for each offense, and each day's operation of such equipment, contrary to said provisions, shall constitute and be regarded as a separate and distinct offense.

"(f) For the purpose of ascertaining any damage by stray electrical currents caused by, first, connections with pipes or other underground metallic work of the city of Chicago or the Sanitary District of Chicago as authorized by clause (b) of this section, and, second, the operation of the companies or any of them to any property of the city of Chicago or the Sanitary District of Chicago after the period provided by clause (d) of this section for electrical rehabilitation and for the purpose of determining the amount of any damage and if the companies or any of them is or are responsible therefor there is hereby created a board, which shall be known as the 'Board of Electrolysis Claims,' and shall consist of three members, one of whom shall be the city electrician, and the second, chairman of the Board of Supervising Engineers, and the third, an engineer appointed by the companies.

"Said board shall hear and determine all electrolysis claims presented by the city of Chicago and the Sanitary District of Chicago. The decision of a majority of the members of said board shall be final and binding on the company or companies and on the city of Chicago, and on the Sanitary District of Chicago on any claim presented by it.

"Within thirty days after said board has rendered its decision on any such claim, the company or companies which caused the damage shall pay to the party entitled thereto the amount determined by said board, which amount so paid shall be charged against the renewal fund of the company liable for such damage."

Methods and Costs of Pavement Evaluation

How an Inventory of the Streets of the Borough of Richmond, New York City, Was Made by Five Survey Parties

By GEORGE W. N. HALLOCK
Topographical Draftsman, Office of Borough President

At the instigation of the Department of Finance the city of New York has recently undertaken to make a complete evaluation survey of the physical improvements on its streets. This work was done in the Borough of Richmond by the Bureau of Engineering Construction of the office of the president of the borough. The methods used and the cost will be discussed in the following article.

Richmond Borough, or Staten Island, one of five boroughs into which the city is divided, comprises an area, roughly, 14 miles long and 7 miles wide. Included within its limits are about 317 miles of public streets, about 100 miles of which are improved with permanent pavement. Of the remainder 90 miles are dirt roads without improvement, except grading, and about 125 miles are macadamized roads. Accurate records of the cost of work done on the streets by the city since consolidation are available, but many of the original improvements were made before that time, and records of such, if they ever existed, have long since been lost. Most of the sidewalks and a considerable portion of the remaining improvements were built by private interests, and in many instances no records, even of the existence of such, are available.

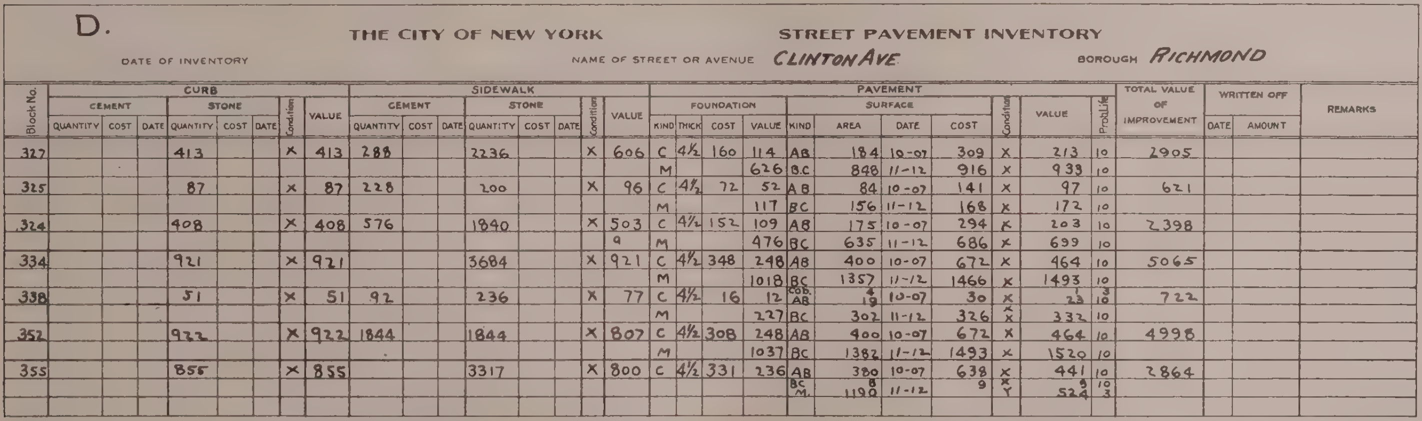
Survey Parties

For the purpose of evaluation it was determined to make a survey, the scope of which would include a rough location of the various types of improvements, their dimensions, and a statement of their condition. In order that this work could be carried on expeditiously the organization of the working force was carefully planned. In the field this force consisted of five parties, in each of which there were a head of party and two chainmen. The supervision and direction of the field forces were placed in the hands of an assistant engineer, who visited the parties and laid out the work each day and to whom the heads of parties reported by mail each night. Accurate progress maps which showed not only the ground covered to date but also the assignment for each party for one or two days ahead aided considerably in avoiding conflict and repetition of work in the field.

Notes were kept on loose leaves (A and B in the illustration), upon which were printed a sketch of a block or an intersection, thus saving the time necessary to make such sketches in the field and adding to the speed and accuracy of the work. The aim was not to get notes that could be plotted but to get the length and breadth of the different pavements, so that the areas could be figured by the computers in the office.

Basis of Measurement

As a basis for measurement each block between house lines and each intersection was taken as a unit, a separate sheet being used for each unit. Field men were directed to note on the sheets before taking any measurements the kind and condition of pavement,

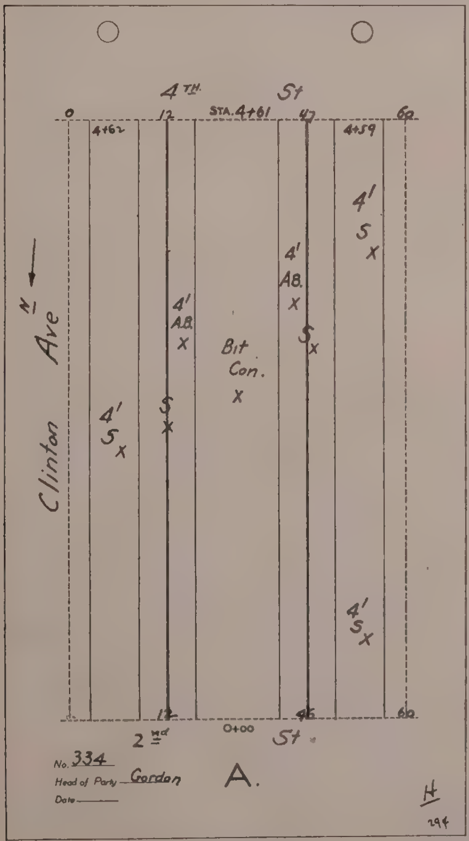


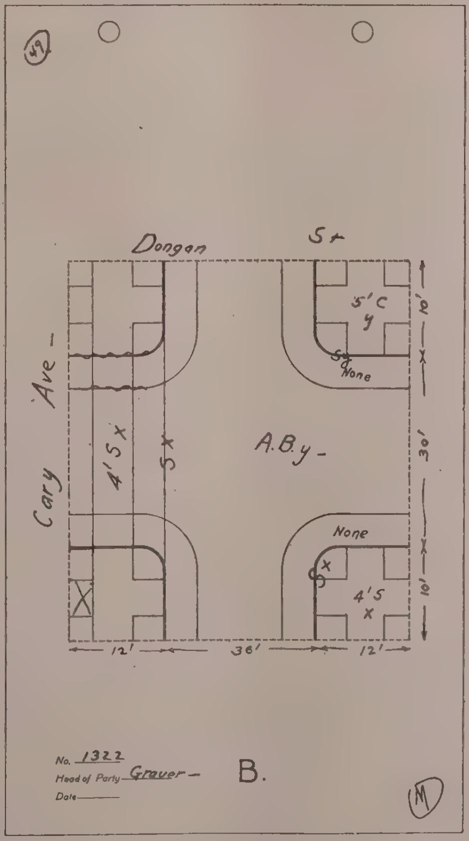
D. THE CITY OF NEW YORK STREET PAVEMENT INVENTORY

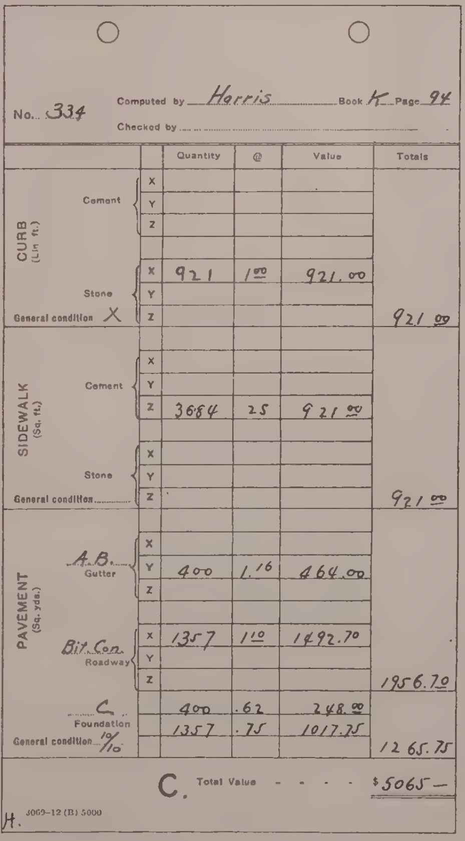
DATE OF INVENTORY

NAME OF STREET OR AVENUE CLINTON AVE BOROUGH RICHMOND

Block No.	CURB								SIDEWALK								PAVEMENT											TOTAL VALUE OF IMPROVEMENT	WRITTEN OFF		REMARKS
	CEMENT			STONE			Condition	VALUE	CEMENT			STONE			Condition	VALUE	FOUNDATION				SURFACE				Condition	VALUE	Prob. Life				
	QUANTITY	COST	DATE	QUANTITY	COST	DATE			QUANTITY	COST	DATE	QUANTITY	COST	DATE			KIND	THICK	COST	VALUE	KIND	AREA	DATE	COST					DATE	AMOUNT	
327				413			X	413	288			2236			X	606	C	4½	160	114	AB	184	10-07	309	X	213	10	2905			
																	M			626	B.C	848	11-12	916	X	939	10				
325				87			X	87	228			200			X	96	C	4½	72	52	AB	84	10-07	141	X	97	10	621			
																	M			117	BC	156	11-12	168	X	172	10				
324				408			X	408	576			1840			X	503	C	4½	152	109	AB	175	10-07	294	X	203	10	2398			
																9	M			476	BC	635	11-12	686	X	699	10				
334				921			X	921				3684			X	921	C	4½	348	248	AB	400	10-07	672	X	464	10	5065			
																	M			1018	BC	1357	11-12	1466	X	1493	10				
338				51			X	51	92			236			X	77	C	4½	16	12	Cob. AB	4 19	10-07	30	X	1 23	3 10	722			
																	M			227	BC	302	11-12	326	X X	332	10				
352				922			X	922	1844			1844			X	807	C	4½	308	248	AB	400	10-07	672	X	464	10	4998			
																	M			1037	BC	1382	11-12	1493	X	1520	10				
355				855			X	855				3317			X	800	C	4½	331	236	AB	380	10-07	638	X	441	10	2864			
																					BC M.	8 1190	11-12	9	X Y	9 524	10 3				







No. 334 Computed by Harris Book K Page 94

Checked by

			Quantity	@	Value	Totals
CURB (Lin ft.)	Cement	X				
		Y				
		Z				
	Stone	X	921	1.00	921.00	
		Y				
	General condition X	Z				921.00
SIDEWALK (Sq. ft.)						
	Cement	X				
		Y				
		Z	3684	25	921.00	
	Stone	X				
		Y				
	General condition	Z				921.00
PAVEMENT (Sq. yds.)						
	A.B. Gutter	X				
		Y	400	1.16	464.00	
		Z				
	Bit. Con. Roadway	X	1357	1.10	1492.70	
		Y				
		Z				1956.70
	C. Foundation		400	.62	248.00	
			1357	.75	1017.75	
	General condition 10/10					1265.75

C. Total Value - - - - $5065 —

H. 3069-12 (B) 5000

Standard Form for Recording Results of Pavement Evaluation and Specimens of Loose-Leaf Field Notes gutter, curb and sidewalks. A code of abbreviations for the different classes of pavements, etc., was furnished each head of party, the condition being noted by the letters, X, Y or Z (good, fair or poor). The judgment of the head of party was relied on as to the condition, although this was subject to correction by the engineer in charge.

Measurements were taken to the nearest foot, no decimals appearing anywhere in the notes. One-hundred-foot metallic tapes were used, the measurements being taken in the center of the roadway of the street measured. Cross-walks were considered as part of the street pavement and were not measured separately. Angles and skews in streets were not noted.

The field sheets as fast as they were completed were turned into the office for computation.

It was found necessary to measure 117.7 miles of street. Information as to the condition of the remaining streets was arrived at by inspection from an automobile. In the meanwhile the force in the office, consisting at first of three men under the direct supervision of a draftsman, prepared an index map. Each block and each intersection in the borough was assigned a separate number. Bates numbering machines were used for the original numbering, and a thirty-page real-estate atlas of the borough was used as a basis for the map. The atlas was bought unbound, so that a number of men could work on the separate sheets at the same time.

COMPUTATION

As the field sheets were turned in they were identified on the atlas, and the proper block or intersection numbers were inked on them by hand, the numbering machine having been found useless for this work, as the sheets could not be taken in the field in numerical order. When the sheets were identified and numbered they were turned over to a computer and the areas of pavements, etc., were computed. The actual work of computation was done in ordinary blank books, but a summary of the quantities on each block was kept on a loose leaf (C in illustration).

Wherever the records in existence permitted, the quantities shown on these summaries were checked up against the original contract quantities. By this means a very good check was had for practically all of the permanent pavements, as most of them had been constructed in recent years. This method of checking required that the contract quantities, which the records gave in bulk, should be divided up among the different blocks and intersections, and also that corrections should be applied to field measurements to allow for pavements placed by railroads or other public service corporations.

The fact that the corrected quantities as measured in the field in many cases agreed exactly with the contract quantities, and in most cases agreed within 5 per cent, speaks well for the accuracy of the field work.

The summary or office sheets served as a basis for the evaluation proper. This was based upon the probable future life of the improvements at any location. The probable future life of such improvements was arrived at by a consideration of the traffic conditions, the present conditions of the improvement, and the history of similar improvements under like conditions. The assignment of this probable-life factor was made by the engineer in charge, a man whose experience with the pavements of the borough dates back beyond the year 1898. This probable-life factor was noted on the atlas for each stretch of pavement.

LIFE OF ROADS

In estimating the value of macadam roads the average life of macadam was assumed as eight years and $1 a yard was assumed as its average cost, new. A macadam road that had a probable life of four years was rated as worth four-eighths of $1, or .50 cents a yard.

For permanent pavements it was not necessary to assume an average life, for in most cases the date of construction of the pavement was known. The present worth was arrived at by the formula: Present worth = standard value of new pavement × probable future life ÷ present age of pavement + probable future life.

TABLE 1—PAVEMENT VALUATION, BOROUGH OF RICHMOND

Macadam Pavements

$1 per square yard; life, 8 years.
Present worth = a/8 × $1
a = probable future life in years

Permanent Pavements

Standard values of new pavements, per square yard	
Brick	$2.00
Asphalt block	1.75
Granite block (except those constructed within the past two years, which are valued at $3.50)	2.75
Iron slag block	2.75
Bituminous concrete	1.10
Macadam	1.25
Wood block	2.75
Cobble (gutter)	.20
Sheet asphalt	1.65
Medina sandstone	2.75
Belgian block	2.00
Cement gutters (same as sidewalk)	
Brick gutters (same as brick pavement)	

$$\text{Present worth} = \frac{a}{a+b} \times s$$

a = future duration of pavement in years; b = age of pavement; s = standard value of new pavement

Foundations

$5 per cubic yard	Per sq. yd.
Average thickness 4½ in.	= 62½ cents
Average thickness 6 in.	= 83⅓ cents

Curb Where Permanent Pavement Exists

			Per lin. ft.
Bluestone	X	condition	$1.25
	Y	condition	.60
	Z	condition	.25

Other Cases

Bluestone	X	condition	1.06
	Y	condition	.35
	Z	condition	.25
Cement	X	condition	.70
	Y	condition	.30
	Z	condition	valueless

Sidewalk

			Per sq. ft.
Bluestone flag	X	condition	$0.25
	Y	condition	.20
	Z	condition	.10
Cement walk	X	condition	.20
	Y	condition	.10
	Z	condition	valueless

Engineering adds 5 per cent to the above prices

Standard values of new pavements were based on the average cost of placing similar pavements at the time of the inventory. Such values for various types of pavements in the Borough of Richmond are shown in Table 1.

Foundations, gutters, curbs and sidewalks were assigned values as shown in the table, according to their condition. Foundations and vitrified-brick gutters were found to have suffered practically no deterioration with age, and were valued in all cases as new. The value of the grading was arrived at by assuming a cut of 1 ft. and an average width of 40 ft. for all streets. Taking the unit price of excavation at 60 cents per cubic yard, this gave an average cost of $4700 per mile for regulating and grading. Of course, this result is little better than a guess, but there were practically no data upon which to base a more intelligent estimate. No attempt whatever was made to estimate the real-estate value of the streets. Five per cent was added to all computed values to cover engineering expenses.

TABLE 2—COST OF INVENTORY

Field Work, Summary for Five Field Parties

Men employed	20
Miles measured	117.7
Days worked	23½
Party days worked	98½
Average mileage, each party per day	1.2
Total cost of field work	$1,444.67
Cost of field work per mile	12.275

Office Work

Payroll charge for office force, totaled (Force varied from 3 to 20 men)	2,433.08
Total cost of inventory	3,877.75
Total miles in inventory	317.5
Total valuation of improvements	$6,067,171.00
Cost per $1,000 of value for inventory	.641

The value of the improvements summarized on each office sheet was worked up directly on these sheets. Later this information, in a condensed form, was copied on a sheet of a form which permitted of the grouping of all information concerning the improvements on any particular street (D of illustration). These final sheets were very thin paper, so that duplicates could be made by a blueprinting process.

COST OF INVENTORY

The cost of making the inventory is shown in Table 2. Analyzed briefly, these figures show that the cost for the actual survey aggregated $1,444.67, while the office costs were $2,433.08. The estimated value of the improvement included in the inventory was $6,067,171. The cost per $1000 of value was 64.1 cents.

The seemingly high cost of office work was due to the time that it took to dig out records and the consequent additional labor required. The office force, which at first had consisted of only three, soon grew to twenty to keep pace with the field parties. Had it not been deemed necessary to check up with old records, it is entirely probable that at no time would it have been necessary to have an office staff of more than six men.

The inventory besides serving the purpose of the finance department will be used by the borough officials as a basis for a better and more complete system of pavement records than that which has existed hitherto.

Mr. T. S. Oxholm is engineer in charge of the Bureau of Engineering, and Mr. L. Rabinowitz, assistant engineer, had direct supervision of the inventory in the borough.

Tank at San Francisquito Power Station No. 1

In the letter to the editor by Mr. R. D. Johnson, of Niagara Falls, N. Y., published in our Oct. 11 issue, on page 420, the second equation was incomplete, due to a typographical error. This expression should read.

$$F = \frac{LA}{2\,gC\,(H - CV_1^2)}\left[1 + Z + \sqrt{Z\,(Z+2)}\right]$$

THE 1200-SEC.-FT. IRRIGATION TUNNEL on the Uncompahgre Valley Project will be completely lined with concrete to increase its carrying capacity. This tunnel passes under the Vernal Mesa, which is 2000 ft. high. It carries the waters of the Gunnison River into the Uncompahgre Valley, is approximately 6 miles long and has a cross-section 10½ x 11½ ft. When built, the lining was completed only in one-half of the length of the tunnel; the lining of the invert extended throughout its entire length. It was originally planned to delay the complete lining of the bore until it became necessary to increase the carrying capacity of the conduit by reducing the frictional resistance along its sides. The work, which it is estimated will cost $212,440, involves the placing of 15,600 lin. ft. of side wall and arch lining and 156 ft. of full section lining, including the floor.

Reports Discredit Ozone as Room Disinfectant and Deodorizer

Results of Two Investigations an Attack on "Persistent and Extravagant Claims of Manufacturers"—Comment by Dr. C. P. Steinmetz

OZONE as a gaseous disinfectant and deodorizer—when used in the low concentrations that can obtain in practical room ventilation—is severely arraigned in two reports published in the Sept. 27 issue of the "Journal" of the American Medical Association. These reports present evidence to controvert what are characterized as "persistent and extravagant claims made by the manufacturers and promoters of ozone generators." The first report, embodying the findings of Edwin O. Jordan and A. J. Carlson, of Chicago, asserts that human beings are injuriously affected by amounts of ozone far less than are necessary to produce slight bactericidal action, that ozone is not an actual "deodorizer" but merely "masks" other odors, and that ozone has no place in practical room disinfection. The other report, by Dr. W. A. Sawyer, Helen L. Beckwith and Esther M. Skolfield, all of the California State Hygienic Laboratory, concludes that the products of two well-known ozone machines are irritating to the respiratory tract and mucous membrane and should not be allowed in schools or offices. The machines, it is claimed, "mask" odors and conceal faults in ventilation without correcting them.

CHICAGO EXPERIMENTS

The Jordan-Sawyer experiments were carried out to determine the germicidal action of ozone on pure cultures under the conditions commonly used in testing disinfectants, and to determine the effect of ozone on the ordinary air bacteria. All experiments were conducted in a small room of about 26 cu. m. An analysis was made of the products coming direct from the ozone machine while running at the two different speeds. Speed 1 showed a concentration of 3.5 parts of ozone per million; speed 2 showed a concentration of 8.9 parts of ozone per million. The ozone in the experiments was produced by the ozonator manufactured by the General Electric Company; the type for the direct current rated at about 4250 cu. ft. per hour.

The results of these experiments show that: 1. No surely germicidal action on certain species of bacteria could be demonstrated by the usual disinfection tests with amounts of gaseous ozone ranging from 3 to 4.6 parts per million. 2. The alleged effect of ozone on the ordinary air bacteria, if it occurs at all, is slight and irregular even when amounts of ozone far beyond the limit of human physiologic tolerance are employed.

EFFECT ON ANIMALS AND MEN

When dogs, cats and rabbits breathe ozone in concentration of 10 parts to one million parts of air the immediate effects are restlessness, rapid and irregular respiration and evidence of irritation of the eyes and nasal passages. After from fifteen to thirty minutes' exposure the excitation phase changes into depression and the respiration continues irregular. In from thirty to sixty minutes there is usually some blood mixed with the frothy mucus discharged from the nose. There are individual variations in the resistance to ozone, as some will die of pneumonia, while others recover apparently completely after breathing ozone in concentrations of 10 parts per million of air for two hours. Longer exposures were not tried.

Ozone concentrations of 5 parts per million of air produce similar effects.

Three men served as subjects in one test. The subject sat a few inches away from and facing the ozonator, so that the respired air contained the full concentration of ozone as it came from the machine (5 parts and 10 parts per million, respectively). The exposure to ozone during these tests was sufficient to cause drowsiness and headache. The ozone headache may come on during or shortly after a brief exposure to ozone in greater dilutions; in some cases it comes on two or three hours after the exposure. If the ozone exposure has been rather marked the headache may persist for from two to six hours.

The breathing of ozone in concentrations up to 10 parts per million for short periods not exceeding a total of fifteen minutes produces "sore throat" that persists for two or three days. The "sore throat" is occasionally accompanied by some pain in the chest. These conditions are evidently due to the corrosion of the mucous membrane by the ozone.

Concentrations of ozone of 1 part per million parts of air, according to the report, are certainly injurious, but it does not follow that the weaker concentrations of ozone are proportionally injurious. It is furthermore certain that the animal organism is capable of compensating for or repairing very slight injurious actions of ozone as well as of other toxic substances. It will therefore be very difficult to obtain reliable evidence as to any favorable or unfavorable physiologic action of such ozone concentrations as are practicable in ordinary ventilation.

"MASKING" OF ODORS

Ozone tests were made with reference to these three points:

1. The concentration of the ozone required to mask odors.

2. The possible destruction of odorous substances by ozone in strong concentrations.

3. The possible destruction of odorous substances by ozone in concentrations just sufficient to mask the odors.

The following odorous substances were used: ammonia vapor, hydrogen sulphide, oil of cloves, asafetida, human feces, stale (or decomposed) urine, meat in advanced decomposition, musk, the odor of rose and the odor of lilac.

With the exception of ammonia and the oil of cloves all these odors are completely masked by ozone below a concentration of one to a million. The masking of ammonia and clove oil requires a much stronger concentration of the ozone, a concentration sufficient to cause marked irritation and headache even on short exposure.

Strong concentrations of ozone (from 2 to 5 parts to the million) hastened somewhat the rate of disappearance of the odors of feces, stale urine and decomposing meat. Strong concentrations of ozone are therefore capable of causing some destruction of these odorous substances. In the case of the other odors there was no evidence of actual destruction by ozone in concentrations up to 5 parts per million. Stronger ozone was not tried.

When the assertion is made that "ozone destroys smoke," the average reader takes that to mean that ozone destroys soot. Such an assertion, the report states, is equivalent to a deliberate deception, because there is no evidence that ozone even in the greatest possible concentration can oxidize carbon particles suspended in the air in the form of smoke or soot.

The following is a summary of the conclusions in the report:

Some bacteria are undoubtedly killed by ozone, especially if they are in a moist condition and are in contact for several hours with a current of ozone coming direct from the generator. In practice, however, the fact is of slight importance. Human beings are injuriously affected by amounts of ozone far less than are necessary to produce even this slight bactericidal effect, and there is no evidence for supposing that a quantity of ozone that can be tolerated by man has the least germicidal action. If disinfection of a closed room without inmates is desired, this can be much more effectively carried out by the use of formaldehyde or some other familiar gaseous disinfectant than by ozone. Ozone has no place in practical room disinfection.

Ozone is not an actual "deodorizer" in concentrations that can obtain in practical ventilation. In very great concentrations ozone seems capable of oxidizing some odorous substances so that the odors are diminished or changed, but the change may be in the direction of making the odor more disagreeable. In very great concentrations ozone "masks" most odors by its own intensive odor, and possibly by fatigue or anesthesia of the olfactory epithelium. Certain odors are masked by ozone even in weak concentrations. Ozone does not make "pure air" any more than strong spices make pure food.

In concentrations that appreciably affect man and animals, ozone appears to have uniformly an injurious action. This injurious action is primarily on the respiratory passages. The physiology of ozone points to the conclusion that the use of this poisonous gas as a therapeutic agent is either valueless or injurious.

The conclusions resulting from the tests by the members of the California State Hygienic Laboratory follow.

1. The gaseous products of the two well known ozone machines examined are irritating to the respiratory tract and, in considerable concentration, they will produce edema of the lungs and death in guinea pigs.

2. A concentration of the gaseous products sufficiently high to kill typhoid bacilli, staphylococci and streptococci, dried on glass rods, in the course of several hours, will kill guinea pigs in a shorter time. Therefore these products have no value as bactericides in breathable air.

3. Because the products of the ozone machines are irritating to the mucous membranes and are probably injurious in other ways, the machines should not be allowed in schools, offices or other places in which people remain for considerable periods of time.

4. The ozone machines produce gases which mask disagreeable odors of moderate strength. In this way the machines can conceal faults in ventilation while not correcting them. Because the ozone machine covers unhygienic conditions in the air and at the same time produces new injurious substances, it cannot properly be classed as a hygienic device.

COMMENT BY DR. STEINMETZ

The following comment on the ozone investigations, by Dr. Charles P. Steinmetz, has been published in the "Electrical World":

While I personally do not like the smell of ozone and therefore do not care to have it about, nevertheless some of the conclusions reported by the experimenters appear to me inconsistent, so that it may be well to caution the reader against accepting them without further evidence. For instance:

Guinea pigs were harmed and killed by a very high concentration of ozone, and from this the conclusion is drawn that an extremely low concentration of ozone is harmful. With the same reasoning, since guinea pigs kept in pure oxygen are harmed and killed, the conclusion may be drawn that the 20 per cent of oxygen contained in the air which we breathe is harmful and that we are all in imminent danger of death. Any corrosive non-poisonous agent in sufficient dilution becomes harmless, and while, for instance, the drinking of concentrated hydrochloric acid would be fatal, free diluted hydrochloric acid normally exists in our stomachs as an agent of digestion.

Also, the report states, ozone in higher concentration destroys odors, while in low concentration it "masks" them. It is hard to conceive, without very conclusive evidence, why the action of ozone should be different in one case from its effect in the other.

The experiments with bacteria described are hardly remarkable. I believe any chemist would have predicted that under the conditions of the experiment ozone should have no effect on bacteria.

Ozone is active oxygen, and as such at ordinary temperatures gives many of the reactions which ordinary oxygen exhibits at incandescence; that is, it oxidizes or burns combustibles, such as organic matter. Thus an oxidizable gas, such as the smell of a smoldering tallow candle and most organic smells indicate, should be destroyed sooner or later, depending on the concentration, while a non-oxidizable gas, as, for instance, that indicated by the smell of chlorine or nitric oxide, would not be affected by ozone.

As dryness interferes with chemical action, it should be expected that dry bacteria would be very resistant against ozone. As the action of ozone is oxidization or combustion, bacteria contained in jelly could be affected only by the complete destruction of the jelly. Or bacteria in drinking water containing large amounts of organic impurities could be destroyed only by quantities of ozone sufficiently large to burn up the entire organic matter. For this reason, in water sterilization by ozone, previous filtration is generally used. The last number of "Chemical Abstracts" (Nov. 10) gives a list of nine European cities in which water sterilization by ozone is in successful operation, and abroad such public works are not constructed without previous study of the process by competent scientific authorities.

In view of the rapidly increasing industrial application of ozone, on the one hand, and the many wild claims made for it by quacks and humbugs, on the other, it would in the interest of the electrical industry be extremely desirable if a comprehensive and impartial investigation on ozone and its industrial, domestic and medical use were made by a competent group of scientists. Such investigations, however, could not be carried out by men of one profession only without leading almost certainly to wrong conclusions caused by generalizations from special cases, as I pointed out above. A proper study of the problem, indeed, would require the co-operation of competent physicians, physicists and chemists.

In the literature of ozone at present there seems to be practically no statement which is not flatly contradicted by exactly the opposite statement made by equally high authority.

English Books on Highways Printed in 1712

There was discovered in the Library of Congress recently the first of a work of seven volumes (in English) on highways, printed in 1712. So far as officials in Washington who have examined the work know, all knowledge of the existence of this work had been lost, for none could recall references thereto. The work is largely a translation of the great French work of Nicolas Bergier, which dates from about 1600, though there is much additional matter. Search is now being made in the library for the other six volumes. The title page of the first volume is as follows:

THE
GENERAL HISTORY
of the
HIGHWAYS,
In all PARTS of the
WORLD,
More particularly in
GREAT BRITAIN:
Containing,

I. The Manner of Making and Managing of them by the Carthaginians, Lacedonians, Romans, Indians of Peru, and all other Nations, from the remotest Antiquity to this Time.
II. An Account of Antoninus's Itinerary, and the Peutinger Tables.
III. The just Proportion between the Ancient and Modern Furlongs, Miles and Leagues.
IV. The Original and Advancement of the Post.
V. Canals cut, Bridges built, and Ports made by the Romans.
VI. An Accurate Description of Rome, in Three several Ages.
VII. And lastly, An Account of the Modern Roads in Great Britain: With an Abstract of the Laws concerning them, &c.

LONDON, Printed: And are to be sold by D. Brown at the Black Swan without Temple-Bar; W. Innis at the Feathers in St. Paul's Church-Yard; G. Strahan at the Golden Ball in Cornhill; F. Morphew near Stationers-Hall; and F. King in Westminster-Hall; Booksellers. 1712.

Concrete Pile Specifications

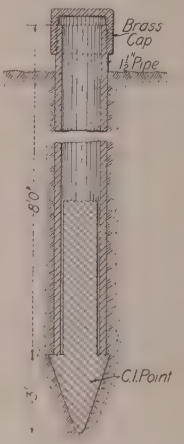
In the abstract of the concrete pile specifications for the Point Bridge, Pittsburgh, published in the Engineering Record of Nov. 22, page 581, omission was made of the fact that in type A piles the pointed mandrel is not permitted to extend more than 12 in. beyond the bottom of the shell and that the alternative use of a cast-iron driving point instead of a mandrel is permitted. These features are pertinent because their omission might, under the conditions obtaining, permit the construction of piles unsatisfactory for the proposed work which they govern.

Railroad Operating Revenue for August on the large steam roads of the United States, as given in a bulletin issued by the Interstate Commerce Commission, amounted to $273,602,765.69, an increase of $3,965,777.27 over August, 1912; operating expenses were $186,533,550.24, an increase of $13,798,064.29; and net operating revenue was $87,069,215.45, a decrease of $9,832,287.02. The operating ratio increased from 64.06 to 68.18 per cent.

Frost-Proof Bench Mark

Establishing Stable Monuments in Swamps at Winnipeg, Canada

Establishing permanent bench marks for precise levels in swamps in a very cold country is generally a difficult and expensive matter. In the northern part of Canada it has been customary to excavate comparatively deep pits, build good-sized concrete piers in them, place the bench mark on the pier and protect it by an inclosing structure. This method did not appeal to Mr. James H. Fuertes, of New York, consulting and designing engineer for the new $13,500,000 waterworks for Winnipeg, Manitoba, where there is to be constructed an aqueduct about 90 miles long, which runs for a considerable part of its length through swamps which in summer are almost impassable and in winter are frozen to a depth of 8 ft. Manifestly, ordinary stakes, steel rods, or shallow monuments will be subject to upheaval and displacement by the action of frost on their sides, and the construction of large monuments with bases carried down deep enough to be beyond the action of frost will be slow and expensive.



Frost-Proof Bench Mark

The difficulty has been overcome and permanent bench marks are established, maintained and displayed at small cost. A shouldered cast-iron point is fitted in one end of a 1½-in. pipe about 9 ft. long which is driven full length into the soft ground by a sledge. The shank of the point is grooved to engage a soft rubber gasket closing the annular space between it and the pipe and preventing the entrance of dirt and water. The top of the standard-length pipe is threaded to enable an additional section to be coupled on if necessary, or to receive a brass cap. The level rod is inserted in the pipe and seated on the flat top of the shank of the cast-iron point and the elevation is taken and stamped on the brass cap, which is carefully screwed in position on top of the pipe projecting a little above the surface of the ground and protected by stones, a box, or any suitable cover. When the ground freezes and thaws the pipe is free to move up and down without displacing the cast-iron point below or disturbing the bench, which is always preserved ready to receive the foot of a rod whenever the cap is removed.

Wood, Coal and Oil as Fuel for donkey engines were subject to comparison in a paper read by Mr. H. W. Sessoms, of the Ebey Logging Company, before the recent logging congress at Spokane, Wash. Scaling the logs used for fuel, he said, showed that a number of logging donkeys used daily 1000 ft. b. m., worth $8 at the donkey. The woodcutter's wage of $2.75 added to this brought the daily fuel cost up to $10.75. When the company had the grates changed to use coal each donkey was found to use 1½ tons daily, which costs, at the rate of $4.25 delivered, $6.38. After using coal for two years, fire risk necessitated converting the donkeys to oil burners, after which the consumption per donkey was 6 bbl. of oil per day at $1.10 per barrel, or a total of $6.60.

Viaduct Floor of Hollow Concrete Tile

Method of Construction Adopted at Spokane to Reduce Dead Load on Bridge Carrying Street over Railways

A VIADUCT having a new type of concrete tile floor, materially reducing the dead load of the bridge as compared with a solid-slab design, is now in course of construction in Spokane County, Washington. The viaduct will serve to carry Trent Road over the tracks of the Spokane Inland and Spokane International Railroads at a dangerous grade crossing, 7 miles east of Spokane.

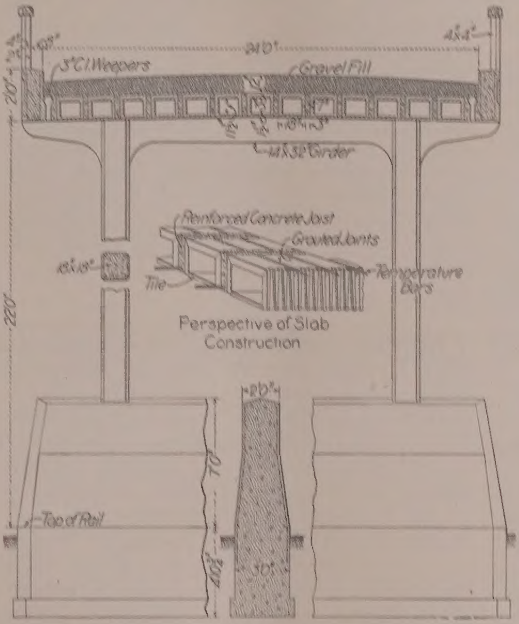
Four lines of railroad tracks cross under the viaduct at an angle of 73 deg. with the bridge, the clear distance from top of rail to the under side of the bridge being 22 ft. The perspective view of the bridge shows the general arrangement of the piers and in the background a bridge on the main line of the Northern Pacific Railroad. The approach of the viaduct from both sides was made by an earth-fill held in place on one side of the roadway by a reinforced-concrete retaining wall and on the other side carried down at 1½ to 1 slope to the present ground level. In laying out the bridge a large saving in the cost is effected by utilizing fill instead of viaduct construction, the length of the viaduct being limited to the points at which a 1½ to 1 slope would bring the toe of the fill 7 ft. 6 in. back from the center line of the two outer tracks. The soil at the bridge site was a good gravel that could be put in place for fill at 25 cents a cubic yard, thus making a 24-ft. fill about 50 per cent. cheaper, according to the engineers, than viaduct construction. The viaduct was designed for a 15-ton road roller or 100-lb. uniform live load per square foot, using 16,000 lb. per square inch as tension in the steel and 650 lb. for compression in concrete. The longest floor slab span is 22 ft. by 3 in.

Heavy collision piers protect the 18-in. square bridge columns against the danger of derailment of passing trains, a precaution which was especially necessary because of a sharp curve in both railroads just north of the viaduct.

A reinforced-concrete stairway was provided to accommodate passengers using the railroad station, just beyond the viaduct.

Features of Hollow Tile.

The principles involved in the hollow concrete-tile floor are explained as follows: Shearing and compressive stresses are transferred from the reinforced-concrete joists to the tile by means of wedge-shaped projections on the sides of the tile. The stresses thus transferred from the joists are then carried from tile to tile by means of wedge-shaped grouted joints on the sides and top of the tile. The wedge-shaped projections on the tile and the grouted joints between them are shown in the perspective drawing. The wedge-shaped joints are also utilized for the placing of temperature bars, which tie the joists and tile together. No concrete is poured on top of the tiles, which form a strong working surface for use while concrete is being deposited.



Cross-Section of Concrete-Tile Viaduct

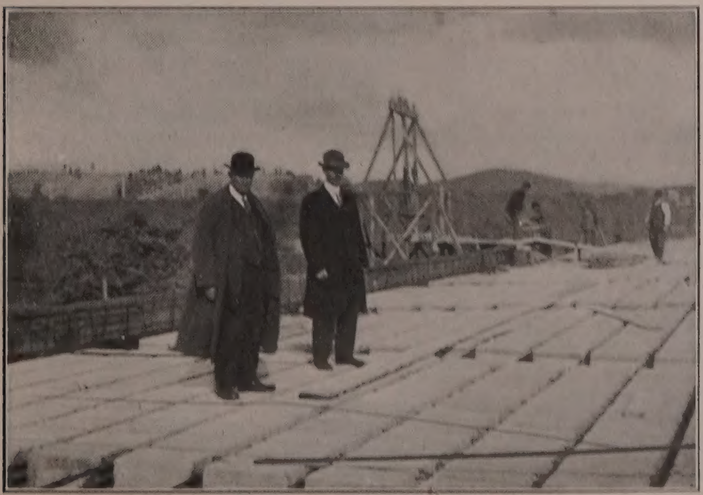
Concrete-Tile Molding

The depth of the slab is fixed by the depth of the tile, as the concrete for joists and girders is leveled off flush with the top of the tile. As stresses produced in the lugs on the tile are those of torsional shear—not diagonal tension—on a section parallel to the tile, and of direct compression on a vertical section at right angles to the length of the tile, they can be readily calculated and the lugs designed accordingly. On account of the wedge shape of the lugs, the wedge being widest at the top, any concentrated load on a single tile cannot displace it, and as the bearing edge of the wedge for shearing stresses is nearly at right angles to the plane of diagonal tension failure, the effective width of the joists for shear may be taken as the thickness of the two webs of adjacent tile and the intervening poured concrete. For the Trent Road viaduct this thickness was 7 in. A slab of concrete tile is designed in the same manner as if the entire cross-section, including concrete in both tile and joists, were deposited as a monolith.

Slabs Tested

In order to test the accuracy of the theory outlined above, and especially the last statement, two test slabs of equal cross-section and reinforcement were made, one of concrete tile and the other of monolithic construction. Both slabs were made on the same day of the same mixture of concrete and were tested to destruction at the plant of the Spokane Concrete Company on June 27, 1913, thirty days after being poured. The entire test, including the construction of the tile and slabs, was under the supervision of Mr. A. D. Butler, assistant city engineer of Spokane. The load was applied in the form of bags of cement arranged in three piles, with aisles 1 ft. wide between them so as to prevent arch action.

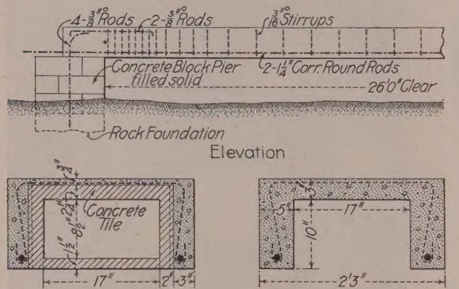
Both slabs had been designed for a live load of 75 lb. per square foot, with tension in the



Tiles in Position Ready for Pouring

Method of Concreting Viaduct Floor

steel of 16,000 lb. per square inch and compression in the concrete of 650 lb. per square inch. The monolithic slab sustained a live load of 508 lb. per square foot at failure, and the concrete-tile slab a live load of 563 lb. per square foot—seven and one-half times the designed live load. In both instances the slabs failed by compression of concrete at the center. The deflection for the concrete-tile slab under a live load of 450 lb. per square foot was only 1.32 in., while that of the monolithic slab for the same load was 1.78 in. Diagonal tension cracks developed in the monolithic slab as a result of the impact of the falling load, but no such cracks appeared in the concrete slab, indicating that the combination slab was the more resistant to diagonal tension. As the concrete slab sustained 11 per cent more load than the monolithic slab, the engineers concluded that the theory of the construction is correct and that in designing such slabs as if they were monolithic the factor of safety is even larger than for poured concrete construction.



Slabs Subjected to Test

Manufacture of the tile was carried on at the bridge site, as the materials for making them were readily obtained near by, the cement being hauled in wagons from the plant of the International Portland Cement Company, the sand and gravel coming from pits in the vicinity. Concrete for the tile was composed of 1 part of cement to 6 parts of carefully graded aggregate consisting of sand and gravel mixed, the particles of the gravel not exceeding ½ in. Only enough water was used to make a damp mixture, well tamped in a collapsible, metal-lined mold, which was immediately removed, the tiles being stored in a shed on wooden pallets until they had cured. During the five-day curing period they were drenched with water twice a day.

The cost of cement, sand and gravel for each tile amounted to 11 cents, and the price charged by a sub-contractor for mixing materials, manufacture of tile and sprinkling during the curing process was 15 cents each. Two men made on an average sixty tile per eight-hour day, including time spent in mixing the materials by hand, removing tile from pallets and sprinkling them during the curing period.

Hartness & Norris, of Spokane, whose bid for the entire work, including about 30,000 cu. yd. of fill for the approaches, was $18,748, were the contractors for the bridge, which was designed and built under the supervision of Mr. J. W. Strack, county engineer, and Mr. C. A. McClung, first deputy. White & Company, of Spokane, bridge engineers, and patentees of the concrete-tile construction, were retained to design and supervise the reinforced-concrete portion of the viaduct.

A Movable Steel Grandstand, seating 8000, is proposed for the athletic field of the University of Chicago opposite the $200,000 concrete structure recently completed.

Book Reviews

The Foreign Trade Bureau of the Philadelphia Commercial Museum has issued a 62-page pamphlet on "Foreign Weights, Measures and Moneys." Following an explanation of the metric system the book gives comparative tables of unit of mensuration in use throughout the civilized world. These tables are commendably complete, emphasizing the activities of the Foreign Trade Bureau in its fields. Of especial value are the conversion tables for the prices of commodities. (Foreign Trade Bureau, Philadelphia Commercial Museum.)

"The Strength of I-Beams in Flexure," by Herbert F. Moore, has been issued as Bulletin 68 by the engineering experiment station of the University of Illinois. The record of the tests of forty steel I-beams, the largest of which were 12-in. 31.5-lb. members, reveals the spirit of comprehensive investigation that has characterized the work at this station. The data on transverse tests, including resistance to sidewise buckling, throw especially valuable light on this little-known subject. Copies of the bulletin may be obtained by applying to C. R. Richards, acting director of the engineering experiment station, University of Illinois, Urbana, Illinois.

Two large volumes issued by the International Association for Testing Materials chronicle the work of the Sixth Congress of the society, held in New York, Sept. 3-7, 1912. The first part of the first volume is devoted to a ten-page review of the Congress, lists of officers, delegates and members, and minutes of the meetings. The remainder of the first volume contains the formal papers and discussion on metals—steel, iron and alloys. The second volume contains the formal papers on stone, cement, concrete, rubber, wood, paints and bitumen and other road materials. There is no continuous paging. The tables of contents show thirty general heads, including various tests. These are indicated in Roman numerals, the papers under each head being indicated by Arabic subscripts. While the bulkiness of the books and the lack of a continuous system of page numbers render the work difficult to handle, the diversity of subjects and viewpoints presented by authors of many nationalities will doubtless compensate those interested in the topics discussed. (Vienna, International Association for Testing Materials, Ernst Reitler, General Secretary; Agents, McGraw-Hill Book Company, New York, and E. & F. N. Spon, Ltd., London.)

The American Society for Testing Materials began in 1903 the study of protective coatings for iron and steel. The reports of the committee assigned to the subject, printed in Volumes 3-13 of "Proceedings" of the Society, have just been assembled and published in a 447-page volume. The first constructive work the committee undertook was in the application, in 1906, of nineteen different paints on the Havre de Grace Bridge. Much has since been accomplished in the study of paints. The producing and the consuming interests have about equal representation on the committee, insuring fair consideration of the entire subject, and probably there is no other single book which contains so much original information on paint. There are, in fact, numerous tables, classifications and analyses available nowhere else except in the regular annual reports of the society. (Philadelphia, American Society for Testing Materials, Edgar Marburg, Secretary-Treasurer. Cloth, $2.50.)

Scientific American Reference Book. Compiled and Edited by Albert A. Hopkins for Part I, Statistical Information, and A. Russell Bond for Part II, Scientific Information. Cloth, 5½ x 7½ in.; 597 pages; 1000 illustrations. New York, Munn & Company, Inc. $1.50 net.

This scientific compendium has been enlarged and revised to form the 1914 edition. The greater part is given over to statistical data concerning such topics as social statistics, commerce, the Panama Canal, armies and navies, and aviation, but ample space is devoted to the summarization of scientific information couched in popular terms. This happy faculty of presenting technical information in a form understandable by the layman, retaining the while a fair degree of accuracy, is well illustrated in the discussion of "Time."

Handbook for Heating and Ventilating Engineers. By James D. Hoffman, Professor of Mechanical Engineering and Practical Mechanics, University of Nebraska, Assisted by Benedict F. Raber, Assistant Professor of Mechanical Engineering, University of Nebraska. Leather, 4½ x 6¼ in.: 402 pages; 131 illustrations; 70 tables. New York, McGraw-Hill Book Company. $3.50 net.

(Reviewed by Werner Nygren, Consulting Engineer, New York.)

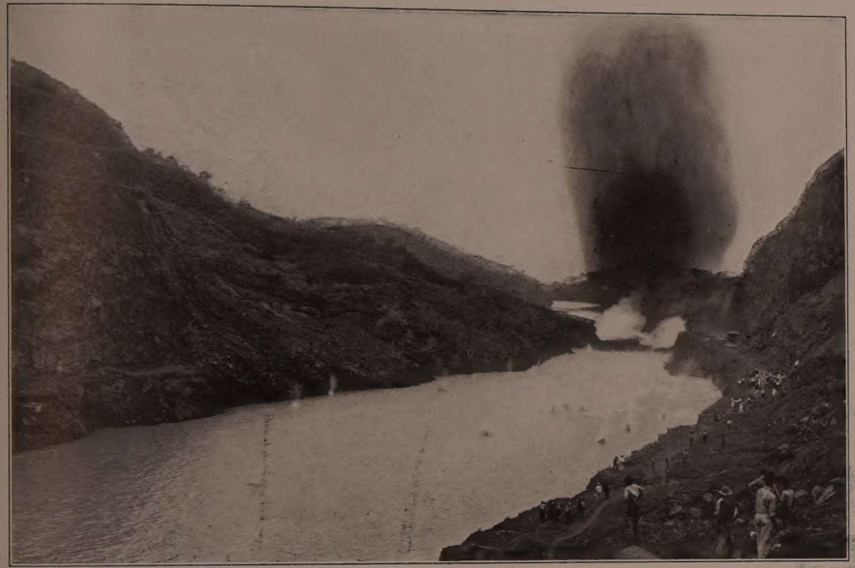
The book in general impresses one as a very carefully prepared volume, covering exhaustively certain forms of heating and refrigeration, and containing information in character and form which might be useful for those who require to refer to a book for both theory and practice. The style and classification of the various subjects are also of such a character that it may be worth having by any engineer who is making a practice of heating and ventilating. The author has handled the subject of direct heating, fan-blast heating, district heating and refrigeration carefully and exhaustively, but has barely touched upon the subject of indirect heating by steam or hot water, which is extensively used for private residences, and has practically ignored the subject of heating and ventilating by the combination method. By the combination method is meant the prevailing method of installing steam or hot-water heat for heating purposes, together with ventilation by mechanical means, introducing fresh tempered air at about room temperature for ventilating purposes only. It is to be regretted that these two departments have not been given the same thorough treatment in the book, as both enter most extensively into the very best practice. They are also the two most difficult departments for an engineer to handle.

While the book contains data applicable to the functions of these two departments which will enable the experienced engineer to find in the book formulæ and data for reference, it would have been more instructive for students or young engineers, who are apt to accept things too literally, if the lacking subjects had been fully covered and illustrated.

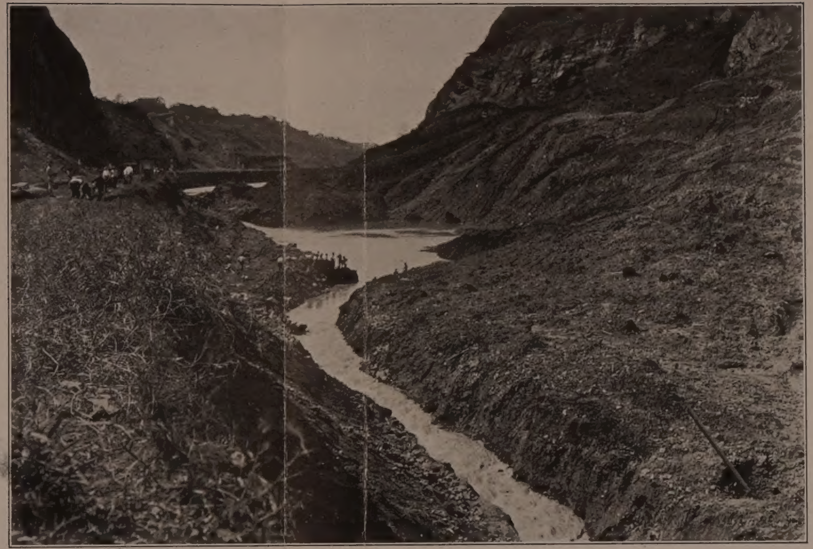
The book is sufficiently elementary in theoretical explanations and sufficiently advanced in practical illustrations of the subjects dealt with to make it very comprehensive, but is somewhat lacking in scope for the benefit of those who are most apt to look to a book of this kind for information and guidance. The author has covered the subjects with which he has dealt very thoroughly—so thoroughly, in fact, that the book might, in a sense, be considered a treatise. He has been very painstaking in reinforcing his arguments and formulæ with authorities, but has carefully avoided expressing his opinions regarding preferable methods for specific cases of heating and ventilation.

THE YEAR'S RECORD AT PANAMA — VIEWS OF FINAL STAGES AND COMPLETED STRUCTURES

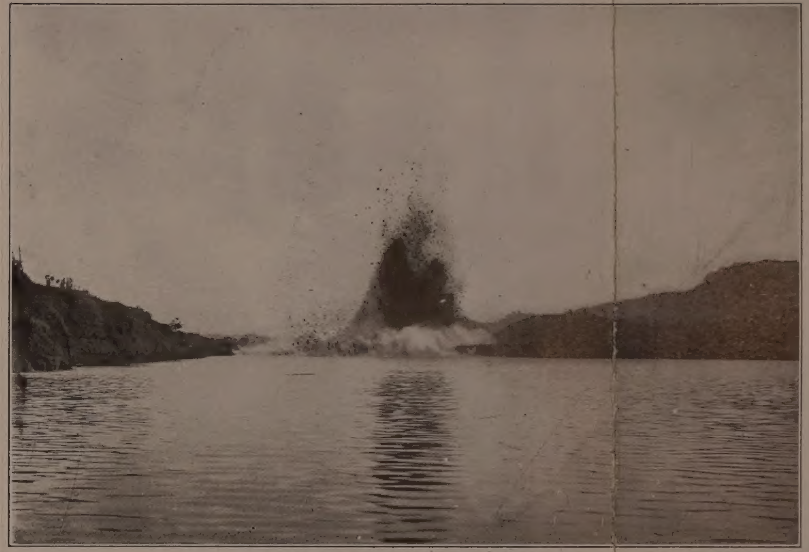
Supplement to Engineering Record, December 6, 1913.



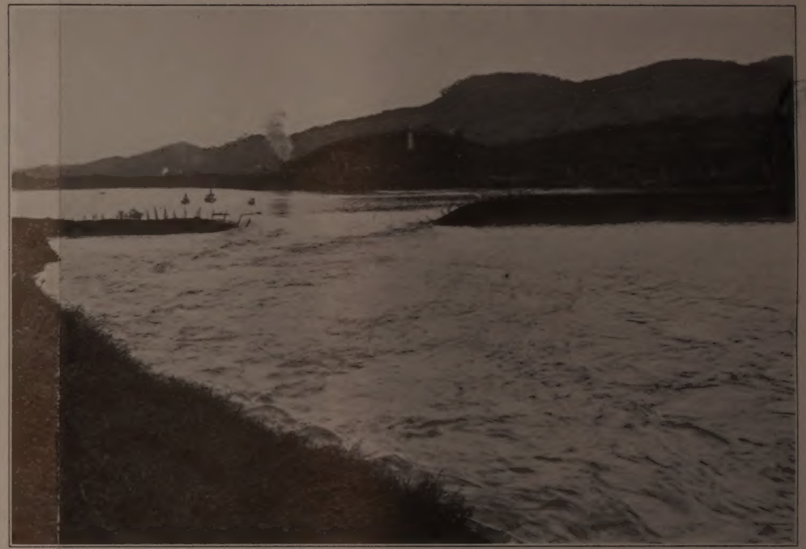
BLASTING ROCK IN CUCARACHA SLIDE, CULEBRA CUT, OCTOBER 10



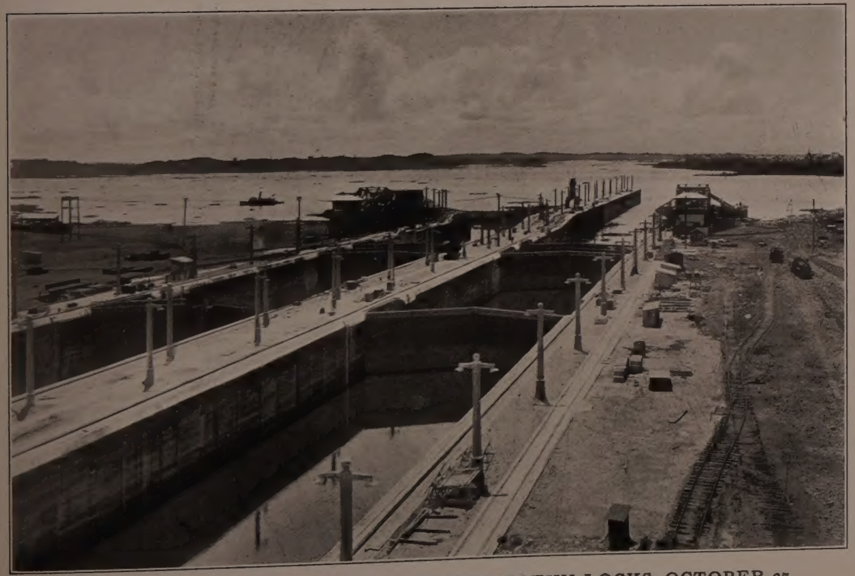
MAKING CHANNEL THROUGH TOE OF CUCARACHA SLIDE, OCTOBER 16



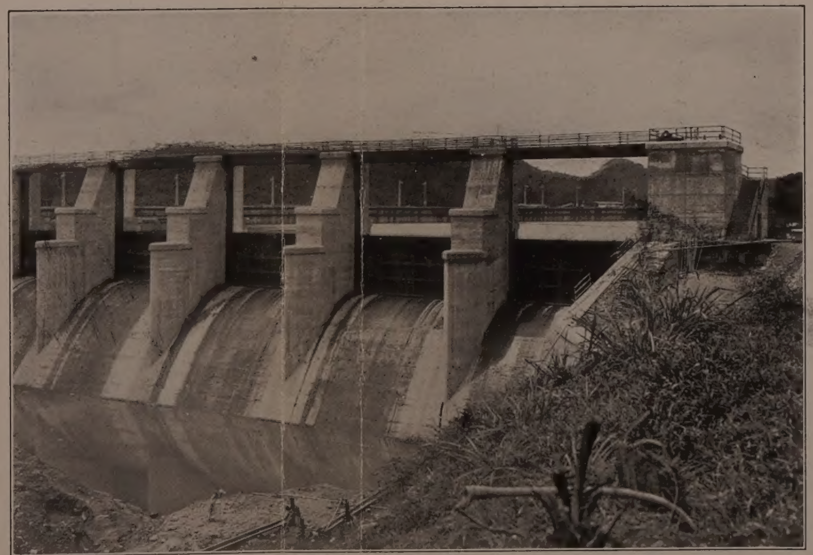
BLOWING UP GAMBOA DIKE ACROSS CULEBRA CUT, OCTOBER 10



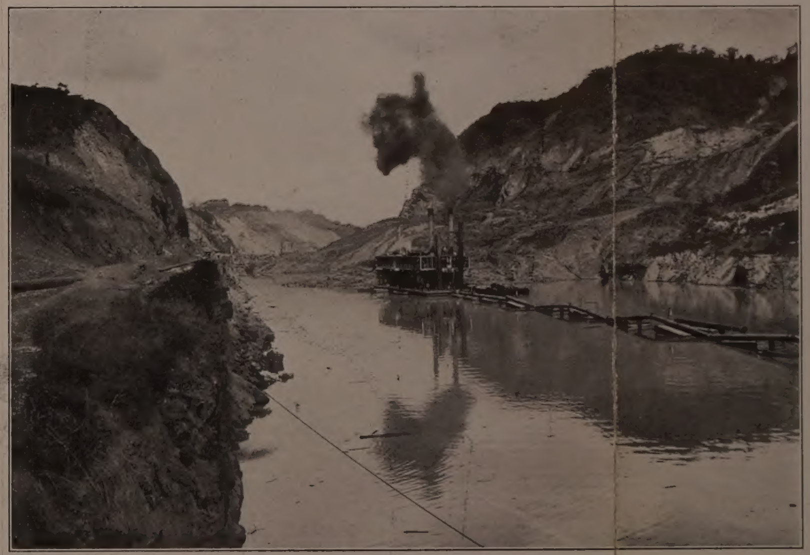
WATER ENTERING CUT THROUGH GAMBOA DIKE, OCTOBER 10



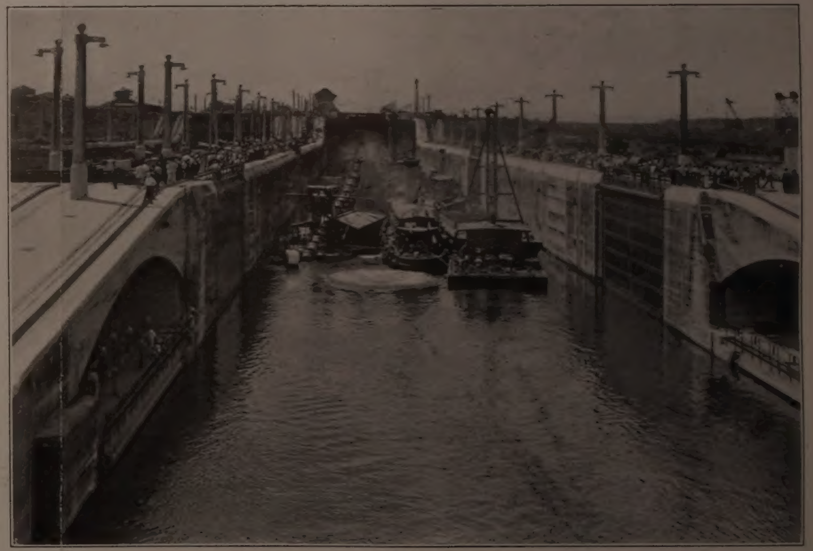
WATER IN WEST CHAMBER OF UPPER GATUN LOCKS, OCTOBER 27



MIRAFLORES SPILLWAY; 8 FEET OF WATER ON CREST, NOVEMBER 5



SUCTION DREDGE REMOVING CUCARACHA SLIDE, OCTOBER 28



DREDGING FLEET ENTERING LOWER LOCK AT GATUN, OCTOBER 9